CALIFORNIA POLYTECHNIC STATE UNIVERSITY

SAN LUIS OBISPO

SENIOR DESIGN PROJECT

MECHANICAL ENGINEERING DEPARTMENT

Final Design Review

RSVP Spaceship!

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June 6th, 2020

Mechanical Engineering CAL POLY

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Executive Summary

This document outlines the Final Design Review of a mechanical engineering senior design project at California Polytechnic State University San Luis Obispo. The project was to design and build a spaceship prop that will deploy during the performance put on by the Sound Design program within the Music Department. This performance, RSVP, is in its 25th year. Dr. Antonio G. Barata, the artistic director and producer of RSVP, is sponsoring the project. The key constraints include keeping the prop hidden in a confined space (under a stage that is comprised of multiple 4 ft. by 8 ft. by 3 ft. panels) for the majority of the show, deploying quietly and reliably, and impressing the audience with the climactic reveal and aesthetics of the prop.

This document serves to ensure this project can proceed into manufacturing and demonstration. The final design has been formed and outlined; a final 3D model has been created with engineering drawings to describe major subsystems. Due to recent events with Covid-19, no new construction and testing on the final design has been conducted as of the final project update on March 12th. The Final Design section, Design Verification, and Project Management have been updated up until this point.

In light of these events, the project has expanded to creating a guide for future theater props. The results have been posted online, with details on the project explained in the Shift in Project Scope section.

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1.0 Introduction

The challenge proposed for our Cal Poly Mechanical Engineering Senior Project Team was to build a spaceship prop for the RSVP production. Our team is composed of four mechanical engineering undergraduate students: Taylor Chavez, Deven Frauenhofer, Andrew Nott, and Zoe Riesen. Our sponsor, Dr. Antonio G. Barata (from the Cal Poly Music Department), is the artistic director. He brought our team in to create this spaceship. As a result of Covid-19, production on the spaceship has been canceled. The project, however, has shifted to creating a theater prop guide based on the work the team has done thus far.

This report is organized into several sections. First, the report overviews the background information related to the problem, which was gathered during our research. Then, we define the project objectives within the project's scope. Next, we outline our ideation process where we formed and evaluated our top concepts. A Manufacturing Plan has been written detailing the steps to manufacture and assemble this final design up until our March 12th project update followed by plan to create a theater prop guide. A Design Verification Plan has been written to explain how the team would have ensured the final product met our specifications. Project management describes our plan for completing major milestones up until the project shifted to creating the theater prop guide. Lastly, the "Proof of concept" chapter contains a description of the work done on the ship until plans have changed. Details on the prop guide can be found in the appendix.

2.0 Background

This section outlines the preliminary research performed in three areas: customer needs, existing products, and technical challenges. Customer needs revolve around constraints of the venue, stage, and schedule (due to the performance date). Because this is a creative performance, no products exist that might pose a patent threat, but we will need to be careful about copyright. The technical research gave us insight into actuation, aesthetic shell design, and special effects.

2.1 Customer Research

We interviewed our project sponsor, Dr. Barata, on October 3rd to gain a better understanding of the requirements and logistics for this project. While the complete notes from the interview are in Attachment A, an outline of notable details follows [1].

- There is no traditional backstage, only a side hall.
- The project must adhere to fire safety codes, verified by the stage technicians.
- If an electrical device is used, the chief electrician would have to be consulted.
- The pilot is about 5'10" and 150 pounds.
- The stage will be comprised of 4 feet by 8 feet panels.
    - These panels could be engineered to be 8 feet by 8 feet, more consultation with the stage technicians is needed.
- The stage will be 3 feet tall.
- The spaceship must remain invisible from the audience until deployed.
- There will be an intermission, which may provide an opportunity for the pilot to discreetly enter the spaceship (rather than at the beginning of the play).
- The spaceship will not need to retract back into its housing, it will remain out for the remainder of the play.
- A floor plan for the 2019 RSVP is shown in Figure 1 (this layout will likely be used in the upcoming performance).

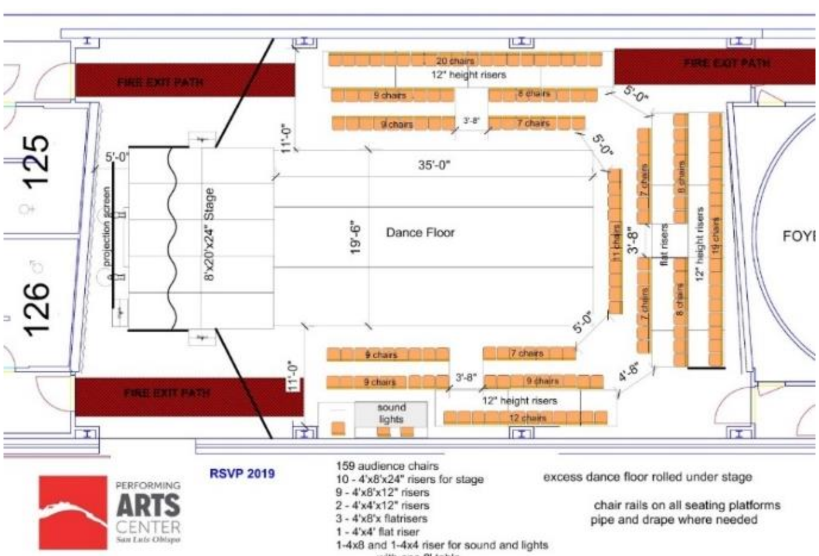


Figure 1. Floor plan for RSVP 2019 [1].

Subsequent interviews were conducted on October 15th and 28th, outlining more details and logistics about the performance and expectations. While the complete notes from the interview are in Attachments B and C, an outline of notable details follows [1,2].

- Marley floor will be used for the dance floor. Castors must meet to code with Marley floor.
- The stage will be 16 feet by 20 feet.
- Pilot props such as a wig and a space helmet will need to be considered.
- A guitar may be included in the design of the spaceship. Considerations for how have gone into the ideation process.
- For spaceship shape forming, Clint Bryson of the theater department would be a worthwhile consultant.

2.2 Product Research

Although our team made efforts to investigate similar products, our research in this domain proved to be unfruitful—as far as we can tell, no one else has created a realistic spaceship prop such as this. To verify this result, we consulted Cal Poly's Engineering Librarian, Sarah Lester. Lester confirmed that it is unlikely that products such as this exist. Additionally, Lester verified that it is unlikely this concept is patented. Lester suggested that some model rockets and spaceship movie props might ultimately influence design aspects of our product and to be wary of copyright infringement will be important later in the development of the spaceship [4]. A complete record of notes from this interview is included in Attachment D.

2.3 Technical Research

For technical research relevant to this project, we looked into three areas of interest: aesthetic shell design, actuating mechanisms, and special effects. Because electrical equipment takes a long process to get approved, we focused on methods of actuation that don't require any electricity.

<u>Shell: Thermoplastics</u>

Thermoplastics are one of the material considerations for the spaceship's shell. These polymers can be melted and recast when heated to a certain activation temperature. Heating for larger sheets is typically done with an oven, while heating for smaller pieces is typically done with a heat gun. Advantageously, touch ups can be done with a heat gun in the case that part of the shell needs to be redesigned.

Worbla, a German brand manufacturer of thermoplastics, details and offers a variety of thermoplastics that may prove useful for the spaceship's design. Worbla's "Finest Art" line has the ability to stretch over curves and has self-adhesive properties, allowing for complex shapes. The activation temperature for these thermoplastics is 195 °F. For structural needs, we might consider a more durable "Mesh Art" line, for which the activation temperature is 175-195 °F.

Finally, Worbla's "Transpa Art" line could be a consideration if windows are required in the final design. This thermoplastic is translucent and stays active longer than the other thermoplastics. The activation temperature is 250 °F [5].

Shell: Fiberglass

Fiberglass is similar to thermoplastics in that a mold is required to form desired shapes. However, unlike thermoplastics, fiberglass does not have temperature constraints. Layers of cloth-like fiberglass are placed over the mold, then painted with an epoxy glue and left to set. More layers can be added for structural integrity, but this shell is aesthetic: only a few layers are needed.

Fiberglass comes in different weave patterns, thicknesses, and chemical compositions for different use cases. C-glass fiber is the most common, while M-glass is more elastic, and Z-glass can be used if a transparent finish is required [6].

This shell is meant to look futuristic and can mimic the look of carbon fiber. The spaceship will not require the structural capabilities of carbon fiber, so fiberglass is an inexpensive alternative. It can easily be painted to a sleek, glossy finish, as seen in Figure 2 [7].

Figure 2. A painted fiberglass shell with the mold used to create it [7].

Shell: Foam/Wood

Expanded Polystyrene (EPS) foam is commonly used for large-scale props. It is rigid, yet easy to mold. The foam is lightweight, and bonds well with paint, leaving a sleek finish [8]. It would be considerably cheaper than sheet metal, thermoplastics, or fiberglass. Additionally, manufacturing would take less time, because this method does not require a mold.

Supreem foam is used as acoustic padding [9]. It might be necessary to place around certain mechanisms on the spaceship to keep the prop within sonic limitations.

Flexply is a moldable plywood, while Jelutong is a softwood that would be easy to shape. Both could be used as a cheap, sturdy alternative for smaller-scale pieces on the spaceship. Any wrap-around items like jet engines, thrusters, a spoiler, etc. would be hard to mold sheet metal, fiberglass, or thermoplastics around. These types of items would be easier to construct out of foam/wood instead.

Shell: Sheet Metal

Actual cars use shaped metal to create their exteriors, but their process uses industrial machinery perfectly designed to produce that car's body panels. For the scope of this project, we would use more simple manufacturing methods. The metal could be thin because it needs minimal structural properties, which would make it easier to cut, fold, bend, and curve into the shapes we need.

This option has the most authentic spaceship/sports car look, but would also be expensive, relatively hard to manufacture, and relatively heavy. It might be best to use it sparingly for key aspects of the prop, such as a nose cone, wingtips, or the hatch. It would add a flashy sheen that is hard to get with other materials [10].

Hinges

Hinges would allow a degree of movement for our mechanisms, most likely a door or hatch. Butt hinges are the most commonly used types of hinge. However, some recess would need to be cut into the door for the hinge to properly function.

A flush hinge would remove this space constraint. Contrasting to a butt hinge, a flush hinge has one leaf fit inside the other, allowing for a more compact mechanism. They are lighter and less sturdy; however, this may not be an issue as the door itself will be made of a lighter material [11].

Pneumatic Actuators

Pneumatic actuators rely on compressed air to operate, so space would be required for air tanks, and they would need to be charged before each show. The actuation itself is loud, but in this case, the "Kshhhhhhh" sound could be perfect for opening the door in the climactic reveal.

A quieter alternative that does not rely on electricity is a hydraulic system. Instead of air, a fluid is used to force the motion. Typically, hydraulics are used when a system has large force requirements: 10-25 times larger than pneumatics. While this spaceship does not have that restriction, the silence makes this option worth considering.

Hydraulic systems can be incredibly simple, with no need for charging or even a tank. In the robotic arm in Figure 3, each motion is simply two syringes connected by a plastic tube [12].

Figure 3. A robotic arm controlled by a series of hydraulic syringes [12].

Theatrical Effects

Various techniques in prop design are employed regularly to perform ‘magic’ on stage. Some categories of techniques that are relevant include prop motion and smoke effects (assuming lighting and sound will be aptly addressed by Dr. Barata’s RSVP team). Within the motion category, some mechanisms to consider using are castors (as shown in Figure 4), hinges, and pneumatic actuators, and within the smoke effects category, we might consider employing foggers, powder puffs, or dry ice [13].

Figure 4. Various castors [13].

Castors are small wheels that can be mounted to the base of the prop. They can be made from different materials to have different effects—we might consider the rubber castor, as it is quiet compared to some of the other alternatives. A castor can provide linear or ‘swivel’ motion depending on the castor type. Additionally, some castors have a locking feature which will likely be useful to hold the prop in place after deployment.

There are many options to consider for the effect of smoke. One option is to make a ‘powder puff’ from corn starch, although the effect is jaw dropping, this method is more difficult to sustain for long periods of time. Another option is to use dry ice. Dry ice is frozen carbon dioxide that sublimates as it warms—meaning it immediately goes from solid to gas, resulting in a misty water vapor. Again, the visual effects of dry ice are impressive; however, there are several drawbacks: ventilation is required to disperse the carbon dioxide gas, the dry ice can’t be handled with bare hands, and, it can’t be purchased too far in advance. Thus, the most reliable option proves to be the fogger. Foggers typically use a glycose base fluid to produce fog. The fogger can be placed directly where the effect is needed (as shown in Figure 5) and, if the correct fogger is selected, it can be controlled remotely. This option is reliable for a relatively low cost.

Figure 5. A small fogger was used to deliver a plume of smoke from the top of this clock [13].

Molds

A mold would be required if thermoplastics, or any equivalent shapeable materials, were used. The following research done evaluates the options and properties of different mold materials.

Softwoods make ideal molds because they are easy to shape. They can be cut, whittled, drilled, and sanded without too much effort. Medium density fiberboard is a good candidate that mixes this manufacturability with a rigid structure that holds its shape during the curing.

High density foam is a commonly used solution. When deciding on foam material, compressive resistance is a primary concern so that the mold holds a constant shape. If thermoplastics are used, the foam must be able to operate past the activation temperature of the thermoplastics, above 195°F for most plastics and up to 250°F. If fiberglass is used, temperature will not be an issue, but a porous material will need a coating to prevent the curing epoxy from impregnating the mold.

Two foam options have been researched. The Corafoam “U-series" [14] and the Last-A-Foam “FR-4700” series [15]. Relevant data for each series has been provided in Table 1. The Corafoam max operating temperature does not meet the requirements; however, the information on density to compressive resistance could be compared to the density to compressive resistance for the Last-A-Foam.

Table 1. Foam Material Data for Corafoam and Last-A-Foam.

Type	Density (lb/ft^3)	Parallel Compressive Resistance @ 70°F (psi)	Max Operating Temp (°F)
U40	4	83	176
U60	6	148	
U80	8	230	
U100	10	290	
U150	15	590	
FR - 4718	18	-	350
FR - 4730	30	-	
FR - 4740	40	-	

3.0 Objectives

This section details the problem we are addressing with this project, the boundaries of the project, the desires of the customer, how we translated these wants into specifications, what these specifications are, and how they will drive the design of our project.

3.1 Problem Statement

Dr. Barata, from the Sound Design Program in the Music Department, coordinates the production of an annual multi-media concert, RSVP. For this year's production, a rockstar shredder will make his grand return in a sportscar-turned-spaceship. This prop must emerge from a tight space under the stage in a sleek and silent manner to maximize the surprise and awe from the audience. Special effects will reinforce this awe factor. The key is reliability: if this prop snags or fails during one of the five performances, the climax will be ruined. Structurally, the prop must be able to hold an adult male. He must be able to get in while the prop is under the stage, exit in the case of an emergency, and exit the prop elegantly once it has emerged.

3.2 Boundary Diagram

To further describe the scope of our project, our team developed a boundary diagram, as shown in Figure 6. A boundary diagram is a visual tool that shows the boundaries of our product and what external surroundings will influence the design of this product. For our design, the dimensions of the stage as well as the passenger of the spaceship are fixed—both these constraints will influence the design. Although it is not imperative that the spaceship sits on the stage following deployment, it is critical that it can fit under the stage, and thus, our design cannot exceed a maximum height of 30 inches. It should be noted that while standard panels for stage assembly are eight feet by four feet, we have the opportunity to design custom panels allowing for a wider range in dimensions for our spaceship—this is why the boundary in our diagram encompasses part of the stage.

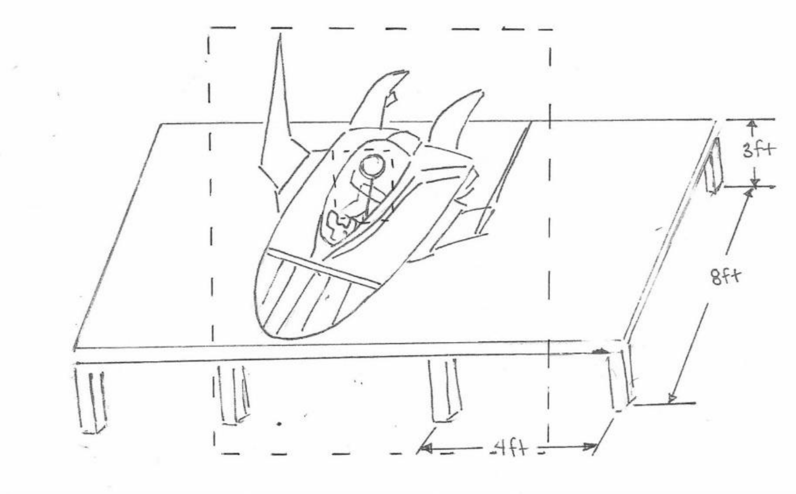


Figure 6. Boundary diagram for the spaceship prop.

3.3 Wants/Needs Summary

Following our discussion with Dr. Barata, our team developed a summary of the associated 'wants' for this product. First and foremost, the final product must be reliable. It needs to deploy fully and must maintain its reliability for a total of five deployments (two to three performances and during rehearsals). It must deploy silently—and in a timely manner—from a hidden location in order to maximize the surprise and awe from the audience. The spaceship must be hidden throughout the majority of the performance, which requires it to fit comfortably under the stage (3.5 feet by 8 feet by 30 inches). The spaceship must accommodate an adult pilot with an approximate height of 5' 10" and approximate weight of 150 lbs. The pilot must be able to enter and exit the spaceship with ease in order to maximize the quietness and speed of deployment, as well as allowing for a quick exit in the case of an emergency.

The aesthetics of the final product are very important. It should look like a sleek spaceship from an old sci-fi movie with design elements from sports cars. It should also include some special effects to increase the "Wow!" factor such as smoke and lights. Ultimately, it must meet any safety requirements for use in the production. And lastly, it must be manufacturable so that it can be built within the timeframe and budget available.

3.4 QFD Overview

Each want and need is weighted for each customer under consideration. Dr. Barata carries the most weight, as he is the primary customer. However, we are also considering the audience, actors/stage technicians, and manufacturers as secondary users. After weighing these needs for each user in a House of Quality chart, we designed measurable specifications for testing each need on the final product. The chart helped us to develop a specification for every need. Additionally, it helped us to realize when a need was more of a design constraint than a testable objective. The full chart can be seen in Attachment E of the appendix.

The House of Quality boiled the customers' desires down to 13 needs, two of which—looking like a spaceship, and looking like a sports car – we decided to keep as design constraints instead of full specifications. Each specification was designed to ensure a need will be met. These are included in Table 2.

We have divided compliance into four categories: test, analysis, and inspection. For specifications requiring inspection, the project will be compliant if, by observation, it falls within the required tolerance. For specifications requiring testing, a test plan will be written for data collection, in order to compare it to our required tolerance.

Table 2. Specifications Table

Spec #	Description	Requirement	Tolerance	Risk	Compliance
1	External length	16 ft	Max.	M	I
2	External width	42 in	Max.	H	I
3	External height	32.5 in	Max.	H	I
4	Internal dimensions	5’10”x2’x1’	Min.	M	I
5	Minimal seat deflection	1in for 150 lb load	Max.	L	T
6	Deployment decibel sound	40 dB	Max.	M	T
7	Mechanism deployment time	60 s	Max.	L	T
8	Initial deployment time	45 s	Max.	L	T
9	Emergency egress	40 s	Max.	H	T
10	Does not snag on stage	Pass/Fail	N/A	H	I
11	Smooth surface finish	Pass/Fail	N/A	M	I
12	Minimal roof deflection	1in for 20 lb load	Max.	M	T, A

H = high, M = medium, L = low; T = test, A = analysis, I = inspection

Specification Description List

1. We will push the prop under one of the available stage sections (4’x8’x3’ without legs).
    a. The spaceship can fit under multiple panels, allowing for a longer length
2. We will push the prop under one of the available stage sections (4’x8’x3’ without legs).
3. The prop must fit under the stage sections (4’x8’x3’ without legs).
4. Once the internal structure is complete, we will ask the pilot to get in.
5. After placing the prop on a flat surface, we will hold a ruler up to the base and load it.
6. We will collect data from 5 feet away with a phone app that can record decibel levels.
7. A timer will be set during the release of the deploying mechanisms.
8. We will set a timer before initiating the deployment sequence, ending it upon pilot exit.
9. We will set a timer and tell the pilot to get out of the prop while under the stage.
10. We will test by pushing our full assembly out from under the stage in the theater.
11. Formed thermoplastic will be visually inspected for noticeable surface roughness.
12. Incrementally increase load on formed thermoplastic to assess deflection.

High Risk Specifications

The majority of our risks are a result of the requirement for audience surprise upon the reveal of our prop. This requirement forces the storage of the prop in a confined space, with reliable deployment. Thus, a constraint of the design is to fit our prop underneath the stage without revealing it to the audience or causing damage to the prop itself. The main risk mitigation technique we will employ is careful design and manufacturing to the specified dimensions. We will also include the Performing Arts Center Stage Technicians in our design process. They are experienced in prop design and aware of the safety precautions to take in order to avoid mayhem.

4.0 Concept Design

This section details the concept development process that led to the formation of our selected design choices. Concept development consists of an ideation phase where we broke down every function to the spaceship and produced relevant concept models. In the idea selection phase, we narrowed down our design choices to a chosen design. Preliminary and risk analysis has begun to show the design will meet specification and safety standards.

4.1 Ideation

Our team began the ideation process with functional decomposition. We chose our overarching function to be "Wow Audience." This effectively means that the prop needs to impress the audience with a dramatic entrance, look, and pilot reveal. We then further divided the functions, as shown in Figure 7.

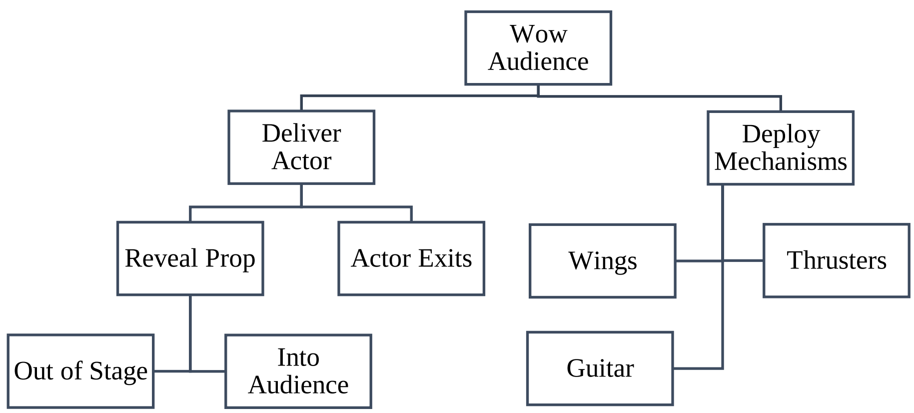


Figure 7. Functional Decomposition.

We verified our functional decomposition methodology through collaboration with other members of our senior project class. Our team then began to ideate by function.

The first method we used was sticky note ideation for how the actor exits. We allowed ourselves 15 minutes to write as many ideas as possible onto sticky notes. A complete list of concepts developed during this ideation session can be found in Attachment F.

In the next ideation session, we used the white boards to ideate on other functions including wings, thrusters, guitar, and lights. We spent about half an hour sketching designs and writing ideas for each of these on the whiteboards. Additionally, we sought feedback and ideas from five random students in our near vicinity. Images formed during this ideation session can be found in Attachment G.

Then, we focused our efforts on the design of the body of the spacecraft. We each sketched our vision of the aesthetics of the spaceship for about five minutes. After the allotted time had passed, we gave our sketches to another team member who modified our initial design for five minutes. By the end of the process, each team member had contributed to four different sketches. Images from this brain sketching session can be found in Attachment H.

Following these ideation sessions, we received input from Dr. Barata on some of the preliminary work we had done. Barata directed us to pursue a design that very clearly represents a spaceship, but subtly ties in sportscar elements—especially in the body design. He stated that his vision of this spaceship has very smooth curves, much like a Corvette [3].

To complete our ideation process, we each constructed about five concept models each out of Legos, K'NEX, foam core board, Play-Doh, and other craft material. Images from this prototype session can be found in Attachment I.

4.2 Idea Selection

After generating over one hundred ideas, our team needed a way to narrow down our choices. We had somewhat narrowed down our ideas after testing for feasibility when creating our concept models. We then used a Pugh matrix to rate our top five to ten ideas for each function. The Pugh matrix imposes a ranking scheme by which each concept is rated better, worse, or the same as a datum concept for an array of specifications. The five Pugh matrices we developed are included in Attachment J.

Once we had narrowed down our ideas by function, we developed a morphological matrix. The morphological matrix allows for the combination of ideas from each function into an overarching design. Our morphological matrix is in Figure 8. The top design ideas derived from this matrix are presented in the Figures 9-16.

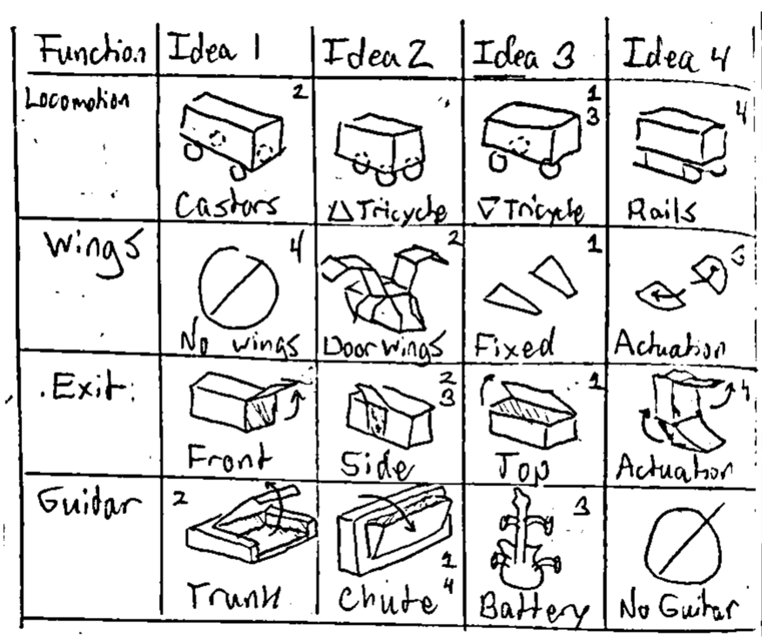


Figure 8. Morphological Matrix.

The design presented in Figure 9 focused on a sleek, fixed-wing shell with a compartment in the rear for a guitar. It has minimal contraptions, with minimal movement on both the guitar compartment and hood hatch. Its simplicity, unlikeliness to snag on the stage, and shell design are the biggest benefits. The problems include no method of pilot entry, likely an awkward exit, and very few showy aspects such as expanding wings or a visible guitar.

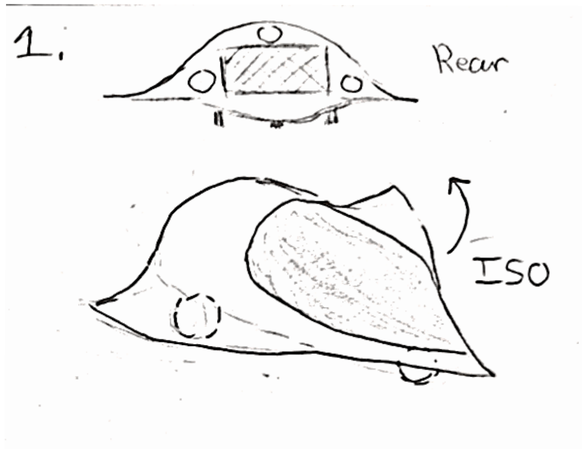


Figure 9. Design Idea 1.

The space we are designing to (3’x4’x16’) is the biggest constraint in this project, and this tubular design, shown in Figure 10, maximizes use of these dimensions. It includes a trunk, doors that open like the space shuttle, and castors rolling it out. Ideally, the prop needs to look more like a spaceship than a rocket ship, and the highly visible castors will take away from both illusions.

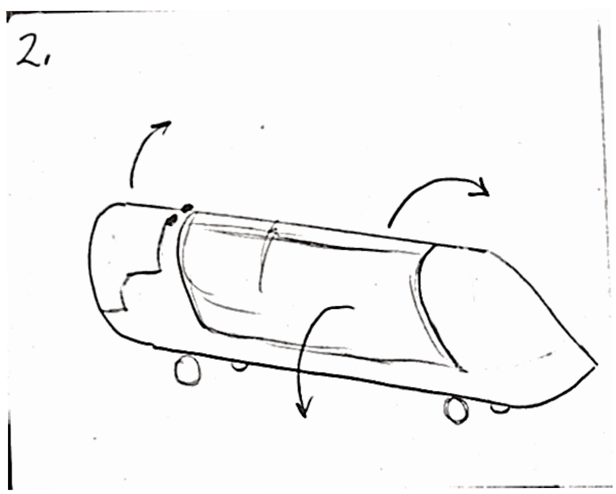


Figure 10. Design Idea 2.

Highlighting the space-car synergy, the design in Figure 11 includes a side door, guitar hood ornament, license plate, and wings that extend out into a step for the pilot to use as he exits. The pilot could enter from the side as well while the prop is still under the stage. The main drawback to this design is that creating actuating wings takes up valuable height space, which we need to maximize just to fit the actor himself.

Figure 11. Design Idea 3.

The design in Figure 12 is all about creating a grand entrance. During the exiting process, the capsule containing the actor is first raised upright, so that the actor is in a standing position toward the front of the craft. Then, the see-through hatch lifts up to reveal the actor, who is then free to descend down a ramp to the stage. While this design creates an impressive effect, it is lacking when it comes to safety, manufacturability, and speed.

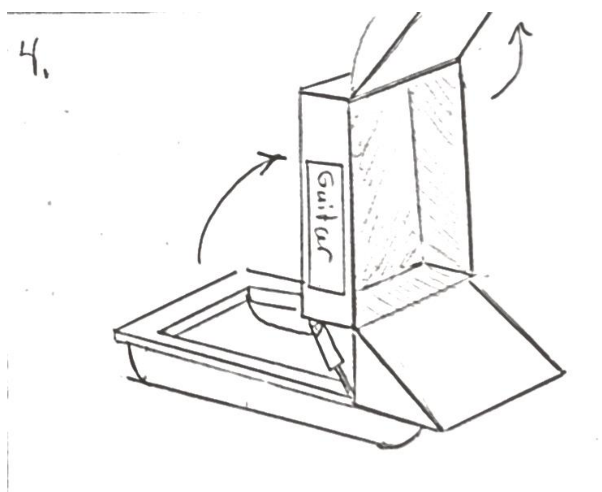


Figure 12. Design Idea 4.

The design in Figure 13 incorporates a more car-like body rather than a spaceship. The car door would allow for an easily manufacturable means for the pilot to exit. A guitar is placed in the front, giving the illusion that it is powering the vehicle. A large thruster is positioned in the back to convey some spaceship like quality.

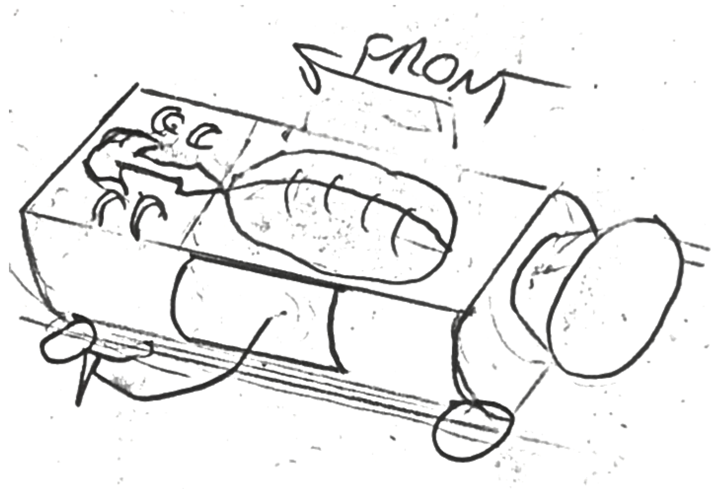


Figure 13. Design Idea 5.

The design in Figure 14 takes inspiration from the DeLorean from *Back to the Future* while having a unique overall shape. On the sides, the doors pivot upward, and at the rear, there is a car like trunk with thrusters on either side.

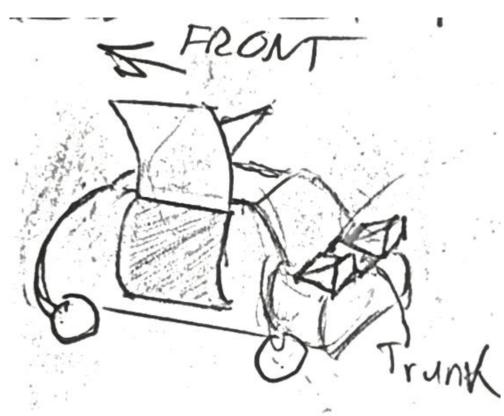


Figure 14. Design Idea 6.

The design for Figure 15 attempts to incorporate smooth curves in the body design. It brings in the concept of doors as wings, and would require some mechanism to raise the wings as or before the pilot exits. Additionally, this design brings in the concept of one large thruster in the rear, and a guitar "powering" the whole system in the front. This is a noteworthy idea with the main drawback being the unconvincing nature of having doors as wings.

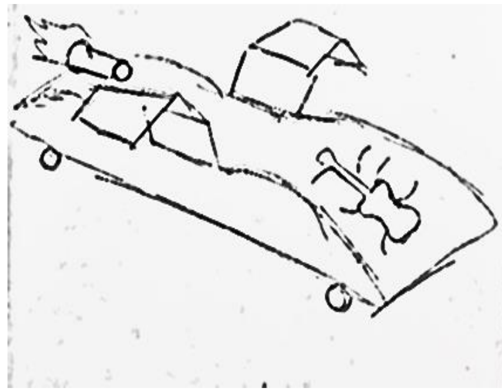


Figure 15. Design Idea 7.

The design shown in Figure 16 fits under the stage with its wings folded up and in half. The actor enters feet-first through the large rear thruster. After rolling out from underneath the stage, the wings are unfolded to their maximum size for the reveal. Then, the wings fold up and the top hatch pivots forward to allow the actor to exit.

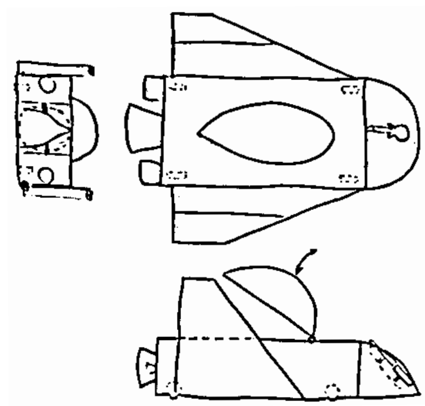
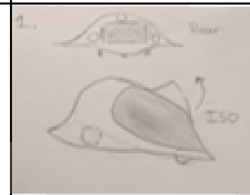
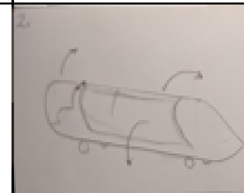
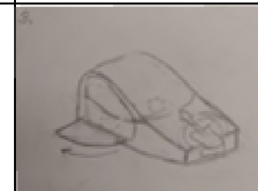
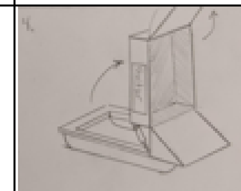


Figure 16. Design Idea 8.

The different combinations from the morphological matrix were then placed in a weighted decision matrix and ranked by adherence to our aforementioned specifications, which can be seen in Figure 17. From our decision matrix, we were able to select our final design, which is discussed in detail in section 4.3.

Design Idea #5 earned the most points in this weighted decision matrix. Its large rear thruster provided the easiest entrance and emergency exit for the pilot out of all the concepts. It is relatively simple, making it more reliable than the alternatives. However, while it fit the sports car aesthetic, our team felt that it wasn't enough of a spaceship. For this reason, we incorporated the shell design and top-hatch pilot exit of Design Idea #1. This design was third place, one of the only three designs to receive over 100 points total. The second place design, Idea #7, was very similar to Idea #5, which is why we did not explicitly combine them.

Team 33: RSVP Space Ship. Scale: 1-5	11/5/2019	Idea 1	Idea 2	Idea 3	Idea 4
Specification	**Weight**				
Deploy Reliably	4	4	4	3	1
Cost	2	5	5	4	3
Support adult's weight (150 lbs)	1	4	4	4	2
Compliant with Spacing	4	3	5	4	5
Emergency Egress	2	2	4	5	3.5
Recognizable as a spaceship	4	5	2	3	2
Special effects (smoke, lights, etc.)	2	3.5	1	2	5
Has sports car design elements	1	1	1	2	3.5
Allow for easy pilot exit	4	3.5	3	4	5
Manufacturable	3	4.5	5	4	2
Total	**135**	**101.5**	**96**	**96**	**86.5**

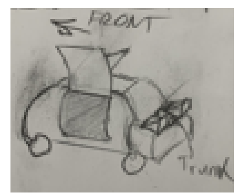
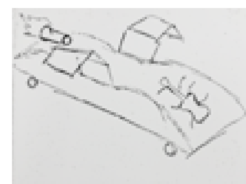
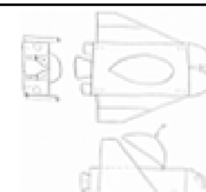
Team 33: RSVP Space Ship. Scale: 1-5	11/5/2019	Idea 5	Idea 6	Idea 7	Idea 8
Specification	**Weight**				
Deploy Reliably	4	4	3	3	2.5
Cost	2	3	4	4	2.5
Support adult's weight (150 lbs)	1	4	4	4	4
Compliant with Spacing	4	4	3.5	4.5	4
Emergency Egress	2	5	4	4	5
Recognizable as a spaceship	4	3	2	3	5
Special effects (smoke, lights, etc.)	2	3.25	2.5	3	4
Has sports car design elements	1	5	5	5	3
Allow for easy pilot exit	4	5	5	5	2
Manufacturable	3	4	3.5	3.5	3
Total	**135**	**107.5**	**94.5**	**103.5**	**93**

Figure 17. Weighted Decision Matrix.

4.3 Selected Concept

The weighted decision matrix showed that Idea 5 had the best mix of functions: a guitar battery, no wings, large rear thruster, castor wheels, a domed window, and a side pilot exit. Upon reflection, our team realized three other aspects were worth pursuing from Idea 1: the sleek shell design, fixed wings, and the alternative exit of a pivoting hood mechanism.

We altered Idea 5 because, without the fixed wings and sleek shell, the prop looked more like a car than a spaceship. It is more important that the audience understands that the prop is a spaceship – any resemblance to a sportscar is a bonus that reinforces the rock star aspect, and the guitar being front and center already captured that motif.

A major paradigm shift occurred at this point of the design: we realized that the spaceship does not actually need to support the weight of the actor. So long as the audience is convinced of the fact that the pilot is in the spaceship, the support for the pilot and the actual spaceship itself can be two separate components. As such, we will be implementing a rear door to allow the pilot to enter underneath the stage. This realization, along with the results of our weighted decision matrix lead to our final design concept, as demonstrated in our computer-aided design (CAD) models and our concept prototype.

<u>Computer-Aided Design</u>

With all this decided, we modelled the spaceship with CAD to check dimensions. This made sure the prop could fit under the stage, the actor could enter it, the actor could fit in it, the actor could exit it, the guitar could fit on the hood, and that we could make it look adequately like a spaceship within the space constraint. Each of these functions and dimensional proofs is shown in the Figures 18-24.

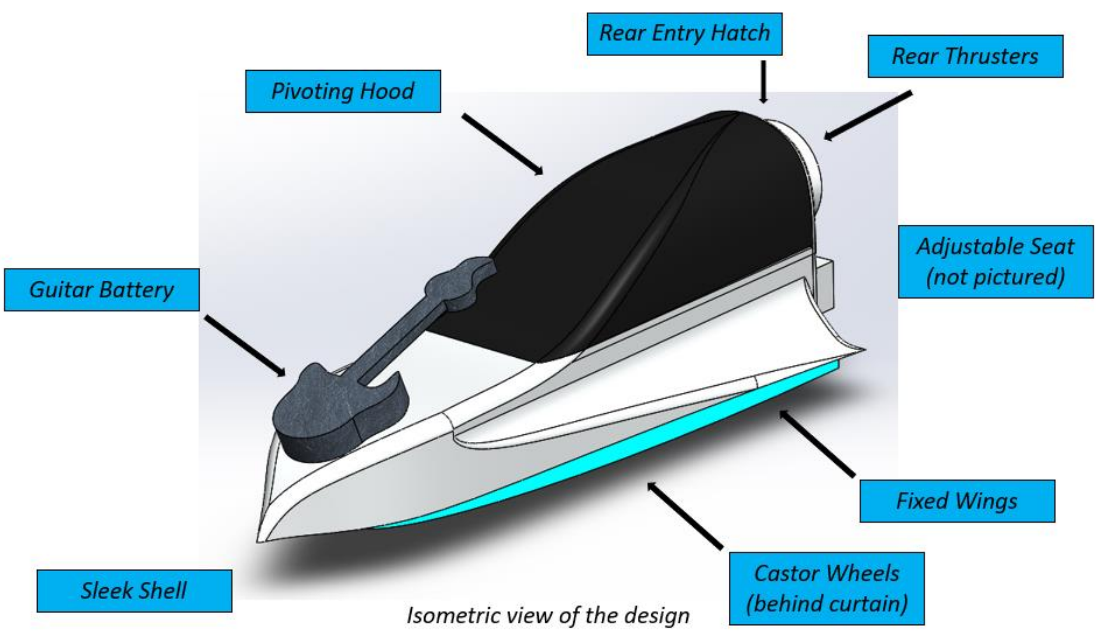
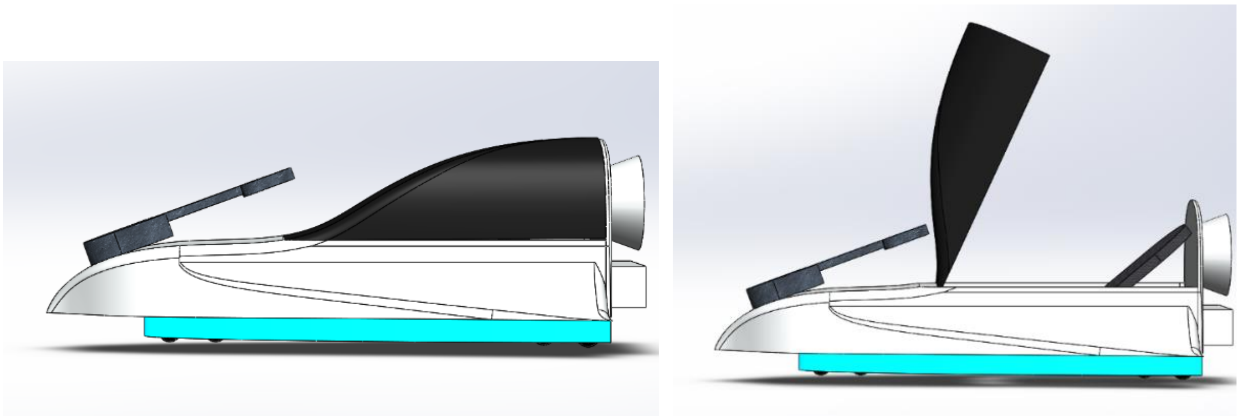
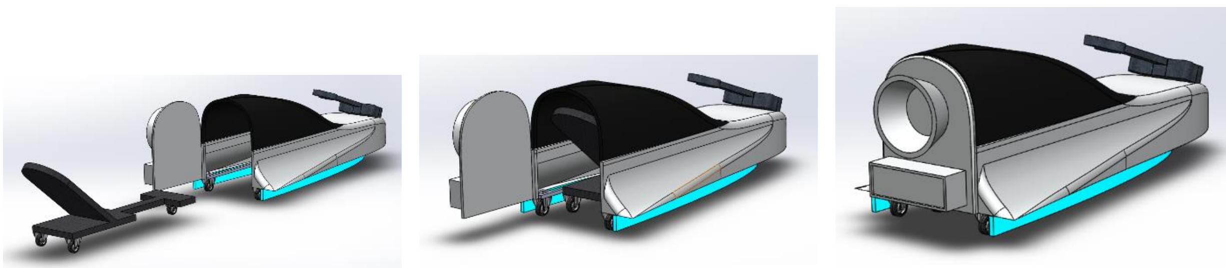


Figure 18. An isometric view of the full prop.



(a) (b)

Figure 19. A side view highlighting the pilot's exit: a pivoting top hatch.



(a) (b) (c)

Figure 20. The three stages of the pilot's entrance. He will (a) sit on the rolling seat, (b) roll into the spaceship, and (c) close the rear hatch behind him.

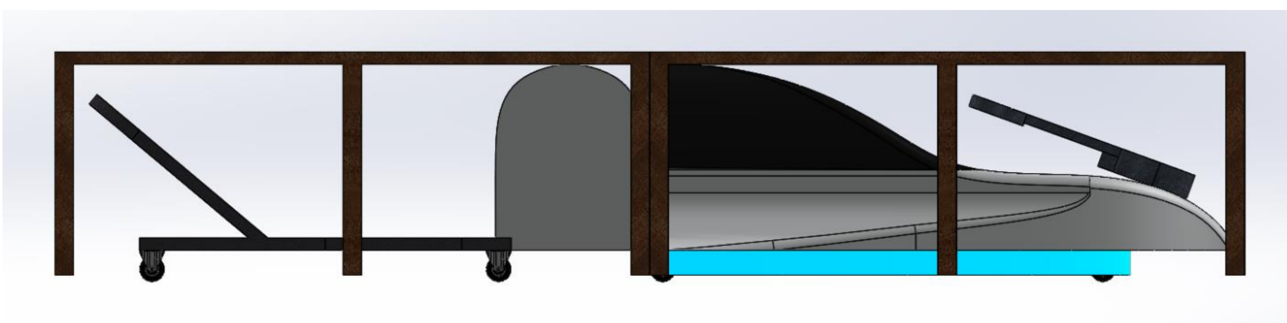


Figure 21. The spaceship and seat spaced under the stage to allow the pilot an easy entrance.

Both the chair and the spaceship itself will be on their own set of castor wheels, allowing them to roll independently. Once the rear hatch is closed and latched, they will roll together. The rear hatch will be closed manually. The top hood may be actuated with a piston or simply by the pilot applying force directly. The guitar is going to be grabbed by the actor as he steps out. A spring or piston will lie behind the guitar, pivoting it up to vertical when needed.

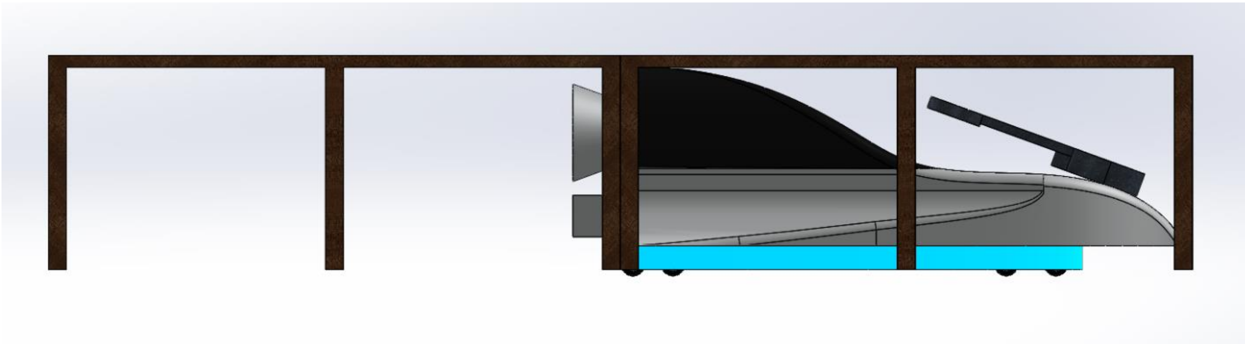


Figure 22. The spaceship ready to be deployed from under the stage.

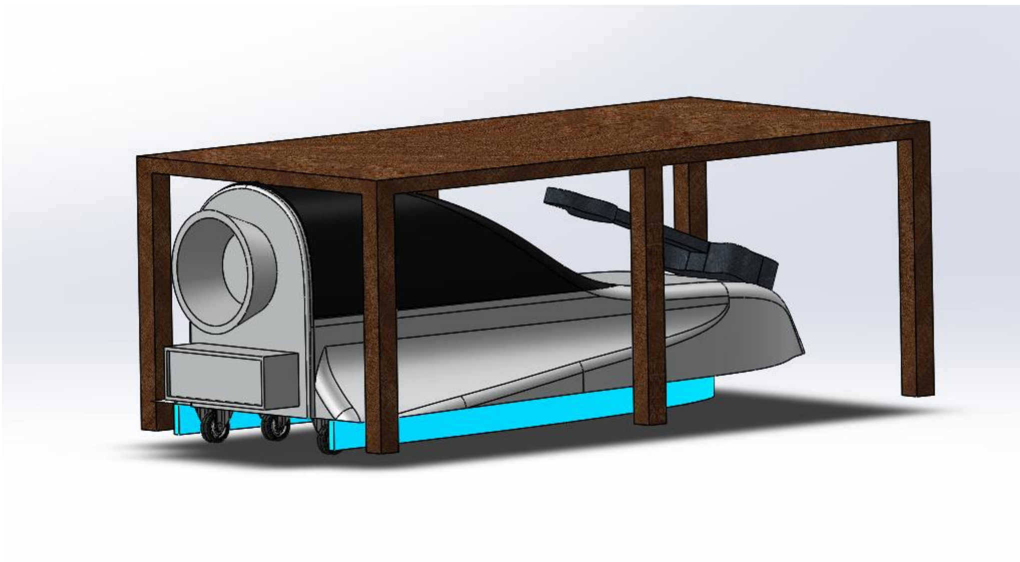


Figure 23. An isometric view showing that the prop fits under a stage section.

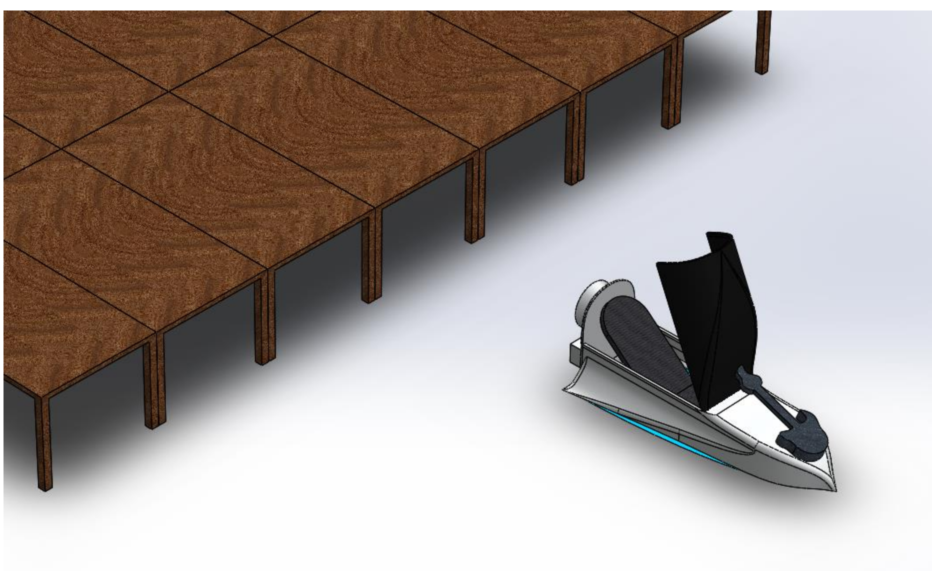


Figure 24. A concept of what the spaceship might look like as the pilot exits.

Concept Prototype

Both Figures 23 and 24 represent the design for a rolling mechanism that will allow the pilot to roll into the spaceship. The pilot can lie back, allowing him to fit under the stage, and manually be pushed into the housing of the ship. From there, both the pilot and the ship can be rolled out together. This design allows for the removal of the ship's floor. This will both give more flexibility with a height constraint as well as eliminate a load issue presented with the pilot standing up on the floor. Holes are cut into the mechanism to easily allow the pilot to stand naturally and elegantly.

This prototype is made simply from a lawn chair mounted on a hardwood dolly with four swivel castors. A simple prototype such as this could actually be used as the final model, because it will never be seen by the audience during the show. However, plans have been devised to build a more sleek, compact design out of wood and castor wheels rated for Marley floor.

Figure 25. Side view of rolling mechanism for entrance.

Figure 26. Top view of rolling mechanism for entrance.

4.4 Engineering Assessment

We wanted to ensure that our concept for a pilot seat would be feasible structurally. To verify this, we prototyped the rolling chair design, as discussed in Section 4.3. A pass-fail test was performed on the design: a team member placed their full weight on the chair. The chair felt stable, did not have visible deflection, and allowed us to roll him around without him falling out.

Additional tests were planned for foam molding and thermoplastic shaping but deemed secondary in importance to the pilot seat test. Because of this, we decided to conduct them between the Preliminary Design Review and the Critical Design Review. They are discussed in detail in Section 5.1.

4.5 Risks and Mitigation

As with any design, it is critical to explore potential risks, so as to avoid them as we continue through the design process. We discussed the risks associated with our chosen design and developed plans to mitigate them. Following our discussion, we completed a design hazard checklist, shown in Attachment M. A summary of our risks and mitigation techniques is found in Table 3.

Table 3. Risks and Mitigation Table

Anticipated Risk	Mitigation Technique
Pinch points when opening door	Padding around pinch points and testing/rehearsal to verify safety
Pilot must get into/out of vessel, which may require an exertion of physical force	Designing an effective chair mechanism for ease of entrance/exit
Pilot will stay in a confined space for an extended period of time	Design and manufacture for as much comfort as possible within a confined space

5.0 Final Design

In this section, we detail every subassembly in the design, review the structural prototype built, and describe how the design fulfills our specifications. After this, we clearly state our plan for safety, maintenance and repair, as well as a summary of our anticipated budget.

5.1 Design Components

Now that the CAD has been completed, this section details the functionality of each subsystem in depth. The prop has two separate rolling parts: the pilot seat and the spaceship itself. The spaceship is comprised of a fuselage, top hatch, rear hatch, thrusters, and guitar compartment (Figure 27). The fuselage is the main structure/body of the ship, while every other subsystem is a mechanism that attaches to it. Together, they will allow the pilot to enter the spaceship under the stage, exit dramatically in front of the audience, reveal the guitar, and start playing it. Detailed manufacturing drawings can be found in Appendix R.

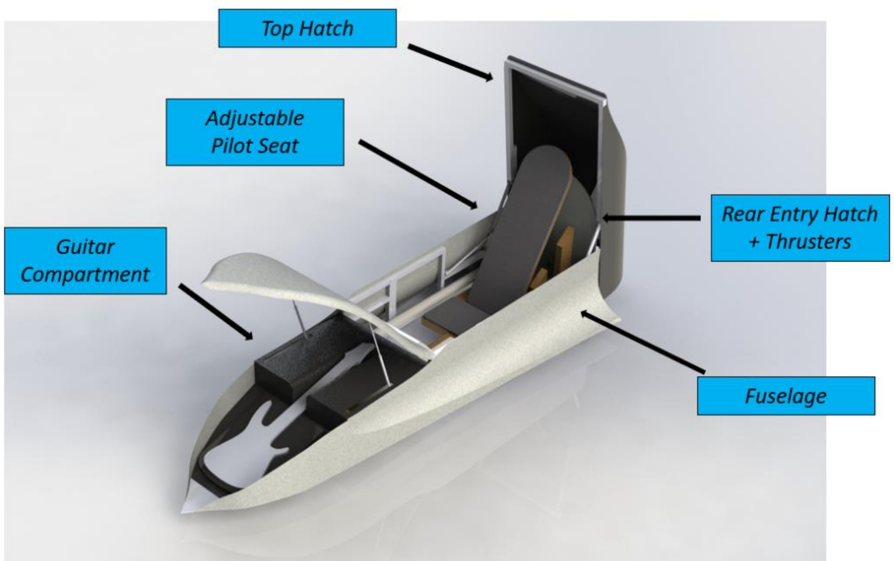
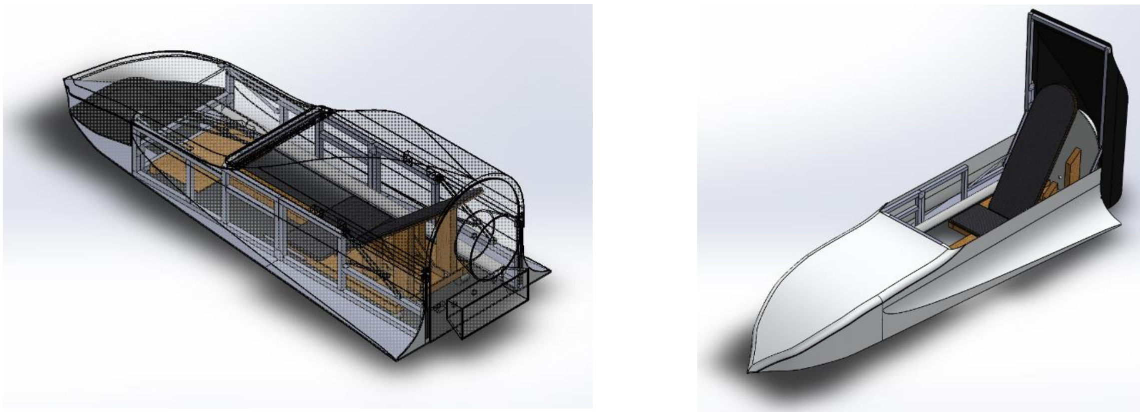


Figure 27. The entire spaceship prop, with top hatch and guitar compartment open.

Pilot Seat

The pilot seat has three constraints: it must support an adult male actor, fit inside the spaceship with this actor, and allow an elegant exit once the prop is deployed. The first two are accomplished by the dimensions of the seat (Figure 28 a). The third required two features: two holes cut into the seat base, and a backrest angle that wasn't too shallow. The two holes allow the actor to stand on the ground, giving the most height and stability possible. The 40° backrest allows the actor to smoothly transition from sitting to standing in one motion (Figure 28 b), while still fitting within the limited interior of the closed spaceship. It rolls in and out of the spaceship on the same model of castor wheels that support the prop.

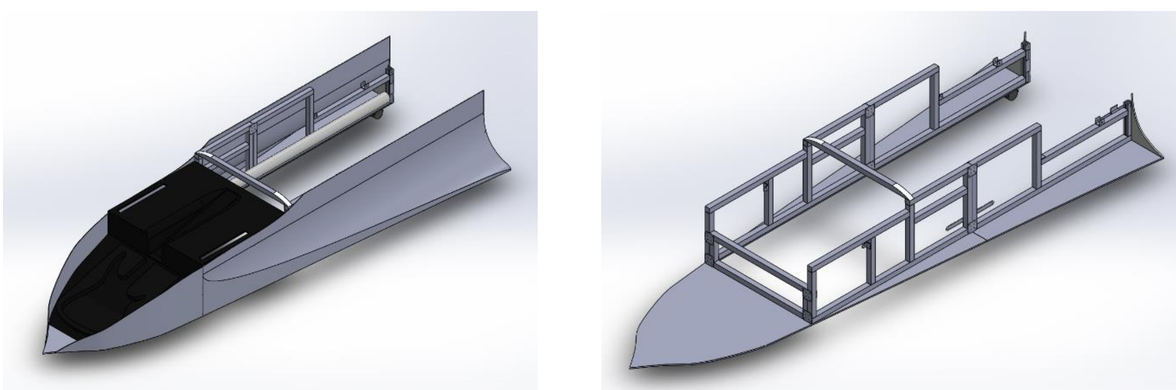


(a) (b)

Figure 28. a) The seat fitting within the spaceship, with enough room for the actor. b) The seat primed for the actor's exit, with foot holes available.

Fuselage

The fuselage's frame is the main structural component of the spaceship. Every other subsystem besides the pilot seat attaches to it. It leaves room for the pilot seat to roll into the center, as well as housing the guitar case, guitar, and fog machine in the nose cone (Figure 29 a). The frame has a series of curved wing supports that wire mesh can be stapled to, creating a mold for the spaceship's aesthetic thermoplastic hull. The entire frame is made from 1x1 inch square wooden dowels, quarter inch MDF, and brackets (Figure 29 b).

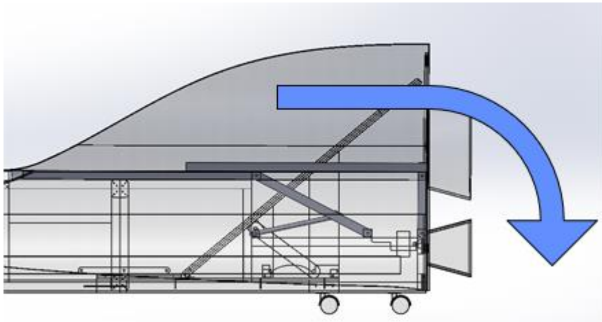
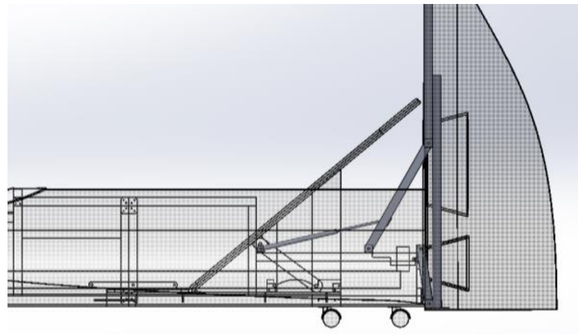
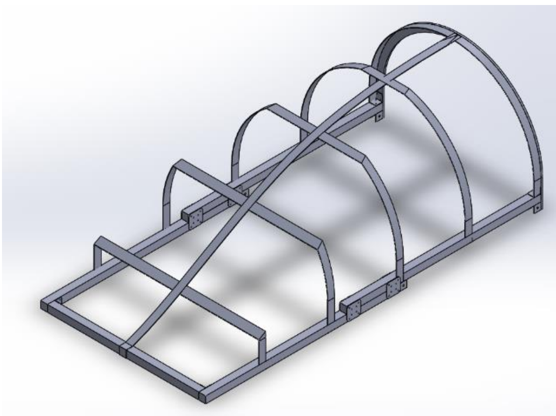


(a) (b)

Figure 29. a) Fuselage with shell and guitar indent. The fog machine is housed under the indent for the guitar. b) Fuselage frame.

Top Hatch

The top hatch pivots on a 4-bar linkage, sliding over the rear hatch like the hood of a convertible. It stays latched in place until the actor is ready to exit the vehicle (Figure 30 a). Once unlatched, two gas springs (one on either side) push the 4-bar linkage into the second position (Figure 30 b). The linkages and base are made of wood, with metal strips attached to it in arcs (Figure 30 c). These metal strips adhere to the tinted thermoplastic window that acts as the aesthetic shell for this entire subsystem (Figure 30 d).


(a)

(b)

(c)

(d)

Figure 30. a) Closed top hatch. b) Open top hatch. c) Top hatch frame. d) Thermoplastic shell.

Rear Hatch

Besides allowing the actor to enter the prop, this hatch must lock in place behind the actor and allow emergency egress in the case of an emergency. It hinges outward to allow the pilot in. It locks in place with a standard gate latch, which can be pulled from a lever within easy reach of the pilot while inside the prop (Figure 31).

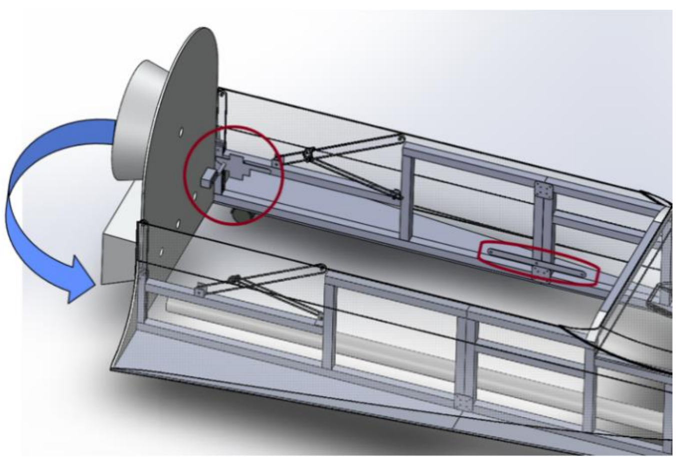


Figure 31. The rear hatch, closed and latched with the gate latch. It will be attached to the small lever on the right with a strong string. Once pulled, the actor can roll out on the pilot seat.

Thruster

The thrusters on the back of the ship jettison fog. This comes from the fog machine in the nose cone, travels through flexible tubing contained within a PVC pipe, and connects to the holes on the rear hatch. Because the tubing is flexible, it will swing with the rear hatch when it opens.

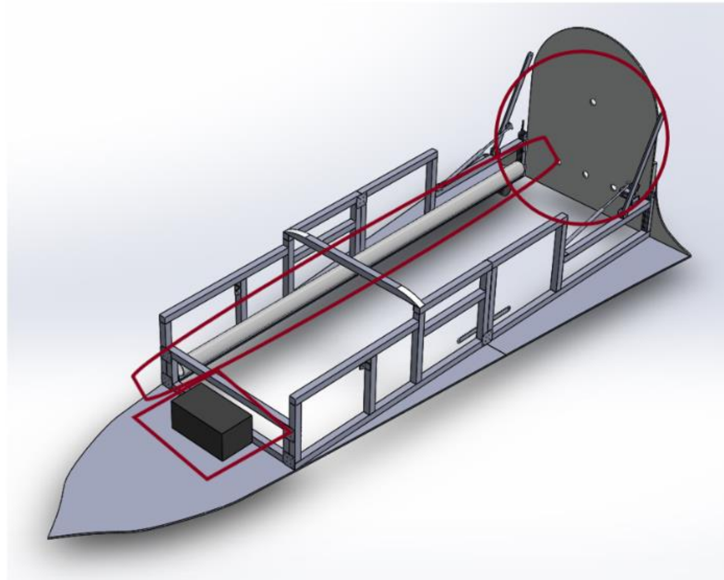
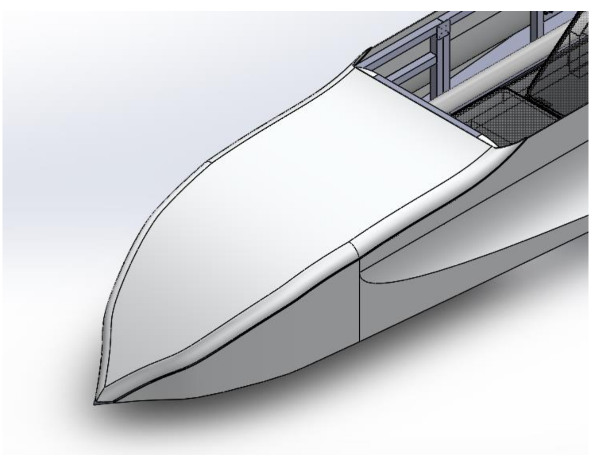


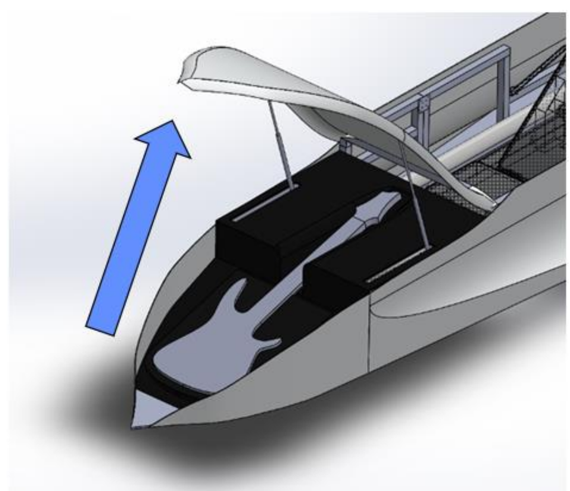
Figure 32. Thruster components.

Guitar Compartment

To allow for a dramatic reveal, the guitar will be hidden under the "hood of the car." It will be housed in an actual guitar case, cut to fit within the prop, to ensure it is not damaged. When closed, the hood will look like part of the spaceship hull (Figure 32 a). However, when the latch is undone, it will pivot upwards on two gas springs. The thermoplastic hood will be made structural with metal strips, and the framing of the prop will be hidden by a sheet of wood covered with the same fabric that is within the guitar case (Figure 32 b).



(a)



(b)

Figure 33. a) Closed guitar compartment. b) Open guitar compartment.

5.2 Structural Prototype

A structural prototype of the rolling mechanism was manufactured and assembled for CDR. The mechanism was constructed with 2 by 2 in. beams, 2 by 4 in. beams, and MDF board. It can be seen in Figure 33 The objective of this prototype was to test the adjustable chair and verify that the rider will not exceed the specified height. To assist in verification, a "box" with the dimensions to simulate the RSVP stage panel was constructed for the rolling mechanism to move under. This structural prototype is likely to continue to the final design if it successfully meets specifications.

Figure 34. The structural prototype of seat mechanism.

5.3 Proof of Concept

The first step in building the verification prototype was the frame. Our goal was to finish this by the end of Winter quarter, ready for display at the manufacturing and test review. We accomplished this, and with a completed frame and pilot seat, the verification prototype was 40% done. Unfortunately, COVID-19 hit immediately after this and the project construction ceased.

Figures 35-37 show the finished frame in sections, with the pilot seat in the two configurations that would have been used in the performance. While this is as much as we manufactured, we did prove that the frame fits under the stage, can fit an actor inside, and allowed the actor to exit gracefully without any problems.

Figure 35. The fuselage frame.

Figure 36. The top hatch frame.

Figure 37. The pilot seat, fuselage, and top hatch assembled together.

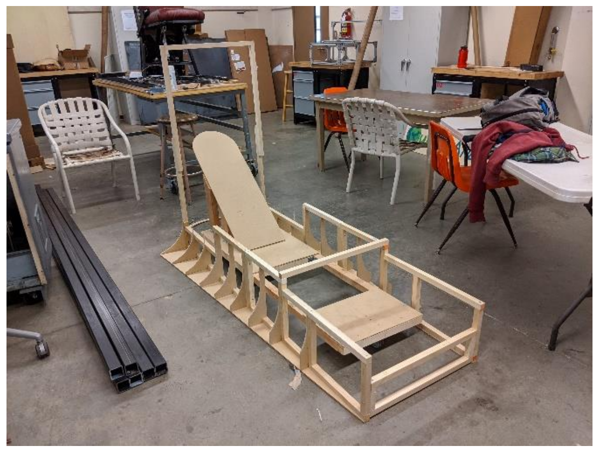


Figure 38. Full proof of concept in the open position, allowing the actor to stand up and step out.

5.4 Specification Fulfillment

All geometric constraints are met by the final design. We built and tested the pilot seat as our structural prototype, and it did not deflect one inch under an adult male sitting on it. This design minimizes decibel levels by 1) using rubber-edged castor wheels meant to avoid squeaking 2) using wood for the majority of our construction, avoiding metallic clanks and squeaks if any mechanisms rub while in motion, and 3) using gas struts instead of piston cylinders, which would have had a loud hiss upon any use, and potential leakage. The gas springs deploy within seconds, and the castor wheels allow the spaceship and pilot seat to be rolled out in under 30 seconds.

Emergency egress is guaranteed by the inclusion of a gate latch with an easily accessible lever that triggers the release. This, combined with the easy-to-roll pilot seat, will let the actor leave in seconds. The ship's hull is designed to be smooth, without any protrusions that could get stuck on the stage curtain while deploying. The wings curve to a point, so they will slide along the legs of the stage if the deployment isn't perfectly straight, rather than getting caught. Finally, the roof deflection is minimized by the metal hoops attached to the wooden base of the top hatch. These results are summed up in Table 4.

Table 4. Specification fulfillment.

Spec #	Description	Requirement	Fulfillment
1	External length	16 ft	8.5 ft
2	External width	42 in	38 in
3	External height	32.5 in	32 in
4	Internal dimensions	5’10”x2’x1’	6’x2’x1’
5	Minimal seat deflection	1in for 150 lb load	Structural Prototype Test
6	Deployment decibel sound	40 dB	Non-squeak castor wheels
7	Mechanism deployment time	60 s	Gas springs
8	Initial deployment time	45 s	30s
9	Emergency egress	40 s	Gate latch + accessible lever
10	Does not snag on stage	Pass/Fail	Smooth outer shell
11	Smooth surface finish	Pass/Fail	Wood and metal framing
12	Minimal roof deflection	1in for 20 lb load	Metal framing

5.5 Safety, Maintenance, and Repair Considerations

Because this prop will only be used for a few performances, maintenance is not a concern. The main components that we anticipate getting damaged are the thermoplastic shell and a part of the frame breaking if someone falls onto it. We chose thermoplastic because it is a forgiving material; if it becomes dented, we can remove it, place it on a mold, heat it up, and the dent will be gone. We made our frame out of wood partially because, if it does break accidentally, it will be easy to unscrew the piece in question, cut a new one, and replace it.

We have complied with every safety guideline required by the theater, such as having no high-power electrical equipment or other fire hazards. As previously discussed, the actor’s safety is a priority, and has been accounted for with the use of a quick release gate latch.

5.6 Cost Analysis

The first page of our Indented Bill of Materials is shown in Table 5. This table provides an overview of our expenses for the final assembly. The entire Indented Bill of Materials can be found in Attachment N, which shows the material costs broken down further. As shown, we spent a total of $1,243.39. Although we still had some expenses to cover, we were well on track to being within our budget allocated by the Baker Koob Endowment ($2000). Due to the COVID-19 pandemic, most of the materials purchased by our team were donated to Cal Poly’s Theater Department and Cal Poly’s Machine Shops.

Table 5. Indented Bill of Materials

Part Number	Assembly Level	Complexity				Total Cost
		Lvl 0	Lvl 1	Lvl 2	Lvl 3	
10000	0	Final Assembly				
11000	1		Pilot Seat			**$38.57**
11110	2			Seat Base		
11120	3			Back Rest		
12000	1		Spaceship			**$630.20**
12100	2			Fuselage		
12110	3				Nose Cone	
12120	3				Wing Frame	
12130	3				Wing Structure	
12140	3				Wing Base	
12150	3				Fuselage Shell	
12200	2			Top Hatch		
12210	3				Top Hatch Frame	
12220	3				Thermoplastic Window	
12300	2			Thrusters		
12310	3				Rear Hatch	
12320	3				Piping	
12400	2			Hood		
12410	3				Thermoplastic Hood	
12420	3				Frame	
13000	1		General Parts			**$442.02**
13100	2			Fasteners		
13110	3				Assorted Wood screws	
13120	3				Brackets	
13200	2			Off-the-Shelf Parts		
13210	3				Wheels	
13220	3				Latches	
13230	3				Pistons	
13240	3				Hinges	
13250	3				Padding	
13260	3				Guitar Case	
13270	3				Fog Machine	
13300	2			Paint and Decor		
13310	3				Window Tint	
13320	3				Thruster Shapes	
13330	3				Spray Paint (for body)	
13340	3				Lights	
14450	3				Other	
N/A		Testing				**$132.60**
					Total Cost:	**$1,243.39**

6.0 Manufacturing Plan

This section focuses on the manufacturing and assembly of our final design. We have broken this section into several subsections including a brief discussion on material procurement, and a manufacture plan for each of the main subsystems: the fuselage, the pilot seat, the rear hatch, and the top hatch. No outsourcing is required for our design. Additionally, it should be noted that the Top Hatch, Rear Hatch, and the Hood were not constructed due to the COVID-19 pandemic.

6.1 Procurement

The majority of materials required for the structural components of our design can be purchased at a home improvement store, such as Home Depot. We plan to source all of our wood, MDF, aluminum, chicken wire, brackets, fasteners, padding, and PVC from this vendor. We plan on getting the castors, hinges, window tint, and gas struts from Amazon. The thermoplastics will be acquired through Worbla, a brand specializing in crafts and cosplay materials. They sell bulk thermoplastic with no shipping cost taking less than a week to arrive. As for the remaining materials, the cotton batting, flexible PVC, and guitar case will be acquired from the online vendors: Joann, Pool Web, and Schecter Guitars, respectively.

6.2 Pilot Seat: Materials, Tools, and Operations

The pilot seat has already been manufactured (see section 5.2). Table 6 shows the materials and tools required for this subsystem and the operations performed are listed below. Operation 3 can be seen in Figure 39.

Table 6. Materials and tools required for pilot seat.

Materials	Tools
2x4” Wood	Table Saw
2x2” Wood	Miter Saw
¼” MDF	Staple Gun
Padding	Cordless Drill
Castors	T-square
Brackets	Compass
Spring Loaded Hinges	
3/8” Wood Dowel	
Fasteners	
Wood Glue	

Operations:

1. Use a T-square and compass to draw out the profile of the backrest on the MDF.
2. Cut out the larger pieces of MDF with a table saw.
3. Cut the 2x4” and 2x2” pieces to length with a miter saw. (The angles can be achieved by changing the cut angle on the miter saw.)

4. Put frame together with 2x4" and 2x2" pieces and attach bottom MDF pieces to frame with wood screws.
5. Attach angled 2x4" pieces to MDF with wood screws.
6. Attach MDF rails to bottom plate using L-brackets.
7. Attach backrest to bottom plate with hinges.
8. Attach backrest strut attachment points to the backrest with L-brackets.
9. Put together strut rod and back rest strut with wood glue.
10. Attach caster wheel plates with a cordless drill and push on the castor wheels by hand.
11. Attach padding with staple gun.

Figure 39. Cutting an angled 2x4" with miter saw.

6.3 Fuselage: Materials, Tools, and Operations

The majority of the fuselage has been completed. The main part of the frame, which surrounds the pilot, is done, while the front portion where the guitar goes hasn't been built. Table 7 shows the materials and tools required for this subsystem and the operations to be performed are listed below.

Table 7. Materials and tools required for fuselage.

Materials	Tools
Thermoplastic	Tin Snips
Chicken Wire	Pliers
1x1" Dowel	Heat Gun
¼" MDF	Miter Saw
Fasteners/adhesives	Band Saw
3/8" Wooden Dowel	Staple Gun
Hinges	Cordless Drill
Padding	Utility Knife
Latch	
Castors	
Guitar Case	
Wood Glue	

Operations:

1. Print profiles of the curved MDF base plates and tape onto MDF.
2. Cut out rectangles surrounding the profiles with a table saw.
3. Cut the curves with a band saw.
4. Cut the wood dowel (beams) to length with the miter saw.
5. Assemble frame with a cordless drill and fasteners, and wood glue.
6. Cut chicken wire with tin snips and shape by hand with gloves or with pliers, secure with staples or by bending it around the frame.
7. Lay-up thermoplastics/use heat gun to form.
8. Secure padding with a staple gun.
9. Cut out inner padded portion of guitar case with a utility knife.
10. Secure to the front of the fuselage with staples/fasteners.

Figure 40. Printed profiles atop MDF sheets.

Figure 40 shows the profiles organized on top of the MDF. We went through two rolls of double-sided tape to adhere the profiles to the MDF!

Figure 41. Cutting out a piece with a band saw.

This method of creating the small MDF pieces with complex geometry (curves, small internal crevices, etc.) turned out to be a time-consuming task. Each one of the pieces required a printed profile which had to be printed, cut-out, and taped. Then, each piece had to be cut out with a band saw with care so that the resulting MDF piece was just larger than the printed profile, as shown in Figure 41. Finally, each piece was sanded using a variety of methods such as hand, belt, disc, and rotary sanding. After going through these many steps for each piece, it seems very likely that the laser cutter would have been a much faster and more precise option for just about every piece that would in it.

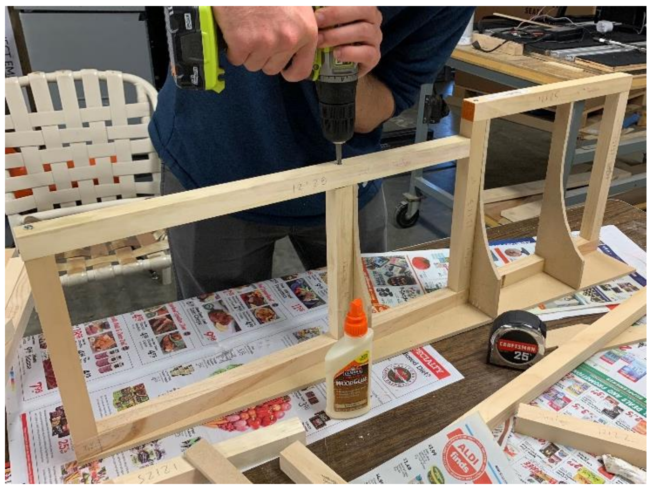


Figure 42. Constructing the frame.

All the mating surfaces of the frame were glued; we then used screws to hold it together while the glue dried, as shown in Figure 42. We only screwed into the square dowel, whereas the MDF pieces were held in place by clamping force from the dowels.

6.4 Rear Hatch (including thruster system): Materials, Tools, and Operations

Some of the manufacturing for the rear hatch will happen at the same time as manufacturing for the fuselage. All manufacturing and assembly of this component should be complete by the end of April. Table 8 shows the materials and tools required for this subsystem and the operations to be performed are listed below.

Table 8. Materials and tools required for rear hatch.

Materials	Tools
¼” MDF	Table Saw
Hinges	Utility Knife
4” Barrel Bolt in Zinc Plate	Wood Glue
Fog Machine	Cordless Drill
2” Flexible Tubing	
2” PVC Piping	
MeshArt Thermoplastic	

Operations:
1. Cut out panels for the square thruster with a table saw.
2. Cut out conical section of thermoplastic with a utility knife for the circular thruster.
3. Print profile of rear plate and cut with band saw.
4. Adhere thrusters to rear plate with wood glue.
5. Attach spring-loaded hinges with cordless drill and wood screws.
6. Run piping from fog machine to thruster outlet.

6.5 Top Hatch and Hood: Materials, Tools, and Operations

Similar to the rear hatch, some of the manufacturing for the top hatch and the hood will happen at the same time as manufacturing for the fuselage. All manufacturing and assembly of this component should be complete by the end of April. Table 9 shows the materials and tools required for this subsystem and the operations to be performed are listed below.

Table 9. Materials and tools required for top hatch.

Materials	Tools
1x1" Wood	Miter Saw
¼" MDF	Table Saw
Clear thermoplastic	Tin Snips
Chicken Wire	Pliers
Cotton Batting	Heat Gun
Tint	Staple Gun
Gas Strut	Cordless Drill
L-Bracket	Chop Saw
1/8" Aluminum Strips	

Operations (Top Hatch):
1. Use the miter saw to cut the 1x1" wood pieces to length.
2. Print the rear arch profile to cut the curved MDF piece.
3. Put together frame with wood screws.
4. Use the band saw to cut out the members of the four-bar linkage.
5. Assemble four-bar linkage with fasteners.
6. Cut aluminum strips to length with a chop saw.
7. Attach aluminum strips to frame with wood screws.
8. Cut the chicken wire to size with tin snips.
9. Use gloves/pliers to mold the chicken wire to shape.
10. Place cotton batting over chicken wire before molding thermoplastic.
11. Melt thermoplastic to mold with heat gun.
12. Adhere tint film to outside of thermoplastic using soapy water.
13. Attach gas struts to the four-bar linkage with fasteners/brackets.

Operations (Hood):

1. Cut aluminum strips to length with a chop saw.
2. Assemble aluminum frame with fasteners.
3. Cut and shape chicken wire with tin snips and pliers.
4. Shape the thermoplastic with the heat gun.
5. Secure the gas struts with L-brackets and fasteners.

7.0 Design Verification Plan

This section details the Design Verification Plan our team has developed to ensure that our final product is operating according to our design specifications. For this section, our specifications listed in Table 2 was reconsidered and updated. Tests were then developed for each specification, as detailed in this section and in Attachment O. Additionally, preliminary testing has already taken place, and the results of these tests are included in this section. It should be noted that aside from the preliminary tests mentioned, the majority of the tests mentioned were not conducted due to the COVID-19 pandemic.

7.1 Testing Summary

The specifications tabulated in Table 2 generally fall into three different categories: will the prop fit the required dimensions (i.e. will the actor fit in the prop and will the prop fit under the stage), will it effectively deploy, and does it meet minimum aesthetic requirements. The first category includes specification #1 through #5, the second category includes specification #6 through #10, and the final category includes specifications #11 and #12. Specification #1 through #3 seek to verify that all external dimensions are tolerable, while specifications #4 and #5 ensure that the prop can support the weight and size of our actor. Deployment time requirements are given in specifications #7 and #8, and deployment sound is limited in specification #6. Specification #9 sets a standard for emergency egress, and specification #10 ensures that the prop doesn't catch on the stage during deployment. Specification #11 ensures that the final design has a smooth exterior surface finish and specification #12 ensures that the exterior can withstand some loading and maintain the aforementioned surface finish. An overview of the tests required for each of these specifications is as follows, however, our complete Design Verification Plan can be found in Attachment O.

For the majority of our inspections, we will make use of the stage and our actor, as these are the most accurate sources for measurement in our case. Inspection is required for specification #1 through #3 and will utilize the stage. The prop will be pushed under the stage to verify that the prop clears all sides of the stage at every point during the push back. A similar inspection is required for the internal dimensions (specification #4): verifying that the actor fits in the chair and that the chair fits within the expected dimensions of the ship. This can be done using our structural prototype and cardboard boxes with the approximate ship dimensions. Specification #6 requires a phone application that can record decibels. We will then measure the levels from a set distance away from the prop as it is being deployed.

Inspection for specifications #7 and #8 requires a timer, the stage, the pilot, the final mechanism, and our deployment team. Once the timer starts, the deployment team will deploy the prop (and actor inside) from under the stage to the desired location on the dance floor. The timer will then be stopped and the time will be recorded. The timer will be reset and started after a cue to begin deploying mechanisms. The timer will be stopped once all mechanisms have been successfully deployed, and the time will be recorded. A similar test will be conducted for the emergency egress: the actor will be loaded into the ship, and then given a cue to perform the egress after a timer has started. The timer will be stopped after the actor has fully exited the vessel. The test for specification #10, or the 'snag test,' will be performed by pushing our full assembly out from under the stage and performing a visual inspection as to whether or not the prop snags on the curtain of the bottom of the stage.

Test 5: The test for specification #5 will require the actor, or someone of similar weight, our structural prototype (the pilot seat) and a ruler—we will measure the initial height of the chair and then determine the deflection from the pilots weight by taking a secondary measurement. Further analysis will be performed to verify we are within required tolerance.

Test 12: A load test will be performed on the roof of the final assembly to determine the load capacity of the formed thermoplastics (specification #12). A can will be placed on top of the ship and marbles will be added into the can. The deflection of the roof will be measured for each incremental load and analyzed.

Preliminary tests have been performed on thermoplastic samples to assess surface finish (specification #11).

7.2 Preliminary Tests

Our team decided chicken wire was an appropriate and affordable mold for thermoplastic shaping. Two types of chicken wire were considered, a 1-inch hex wire and a ¼-inch square wire as seen in Figure 43. Both sets of wire were tested for ease of bending and shape retain-ability. We found that both sets were relatively easy to bend. The 1-inch hex, however, proved to be unable to hold its shape compared to the ¼-inch square. The square wire proved to be able to fold easily in multiple directions without deforming like the hex.

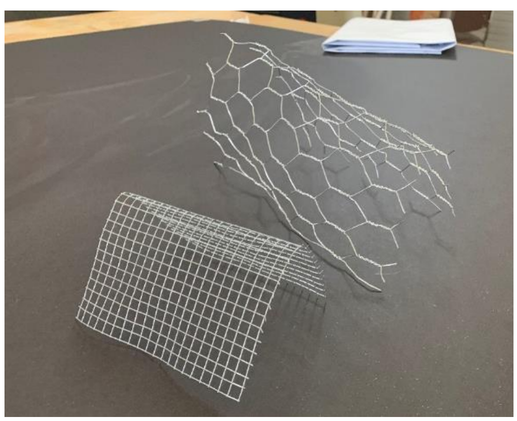


Figure 43. Both types of chicken wire in a sample shape.

The thermoplastic was cut to the same size as the chicken wire, as seen in Figure 44. Notably, before heating, the thermoplastic was fairly stiff and rigid with a slight natural curve. After heated with a standard heat gun, the thermoplastic became much more malleable, as seen in Figure 45 and easily formed to the chicken wire. Heat activation of the thermoplastic was fairly quick—at most, a couple minutes. Cooling took slightly longer: it took roughly five minutes to harden and ten minutes to completely cool. Afterwards, the thermoplastic was removed from the wire mold with relative ease.

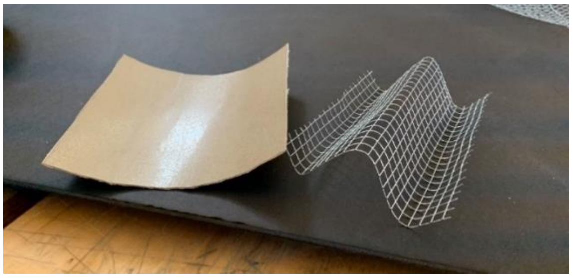


Figure 44. Unheated thermoplastic sheet with chicken wire mold.

Figure 45. Heat gun used to shape thermoplastic.

Two types of thermoplastic, both from the same manufacturer, were tested using this same procedure. The intent of use of the “Mesh Art” thermoplastic is to form the main shell of the vehicle, while the intended use of “TranspArt” is the formation of the windshield. We found that the square wire molding once again outperformed against the hex wire; the thermoplastic laid on the square, as seen in Figure 46, proved to be much smoother compared to the rough and bumpy shape in Figure 47. Using the square mesh, both thermoplastics held their shape, however both were pliable under a tension. Although the thermoplastics will not be providing structural support, this is something to keep in mind moving forward (especially for testing the load capacity on the roof).

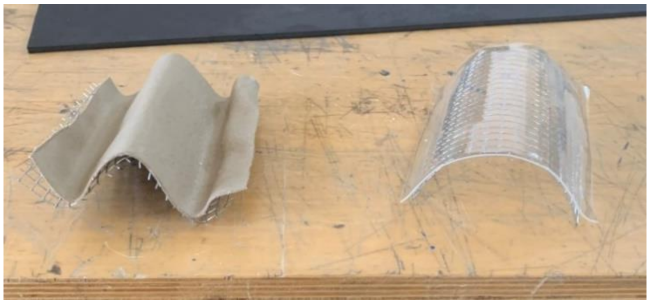


Figure 46. Both the Mesh Art and TranspArt thermoplastic on the square mesh.

Figure 47. The Mesh Art thermoplastic laid over the one-inch hex chicken wire.

In order to decern whether this material could be remolded, the larger piece of Mesh Art used on the hex wire was reheated, smoothed out, and reshaped onto a piece of square wire. We found that most of the bumps from the initial forming were eliminated. Overall, the remold test demonstrated that during manufacturing, it would be simple to touch up the thermoplastic.

Following this test, we considered adding a cotton batting between the mold and thermoplastic in attempt to prevent indentation from the chicken wire in the thermoplastic (this was especially noticeable for the clear thermoplastic). The batting was set up as shown in Figure 48. Trials were conducted for both the Mesh Art and the TrasnpArt.

Figure 48. All three layers of wire, cotton batting, and TranspArt.

The test showed that the cotton batting made a noticeable difference in indentation for the TranspArt, and less of an impact on the Mesh Art. However, we noticed that the batting hindered the thermoplastic from taking the exact shape of the wire. Figure 49 shows the effects of with and without the batting on the TranspArt.

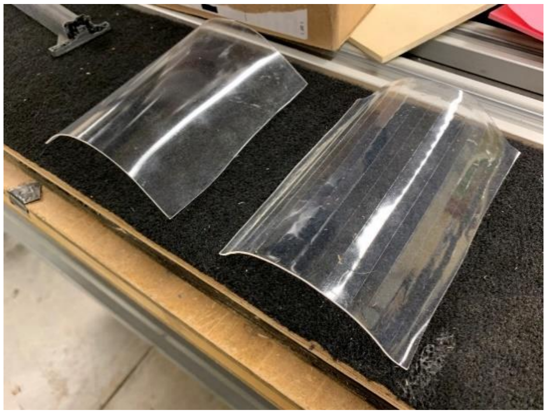


Figure 49. TranspArt with (left) and without (right) cotton batting.

8.0 Shift in Project Scope

The COVID-19 pandemic had a wide-spread impact on everyone around the world. To slow the spread of coronavirus in San Luis Obispo, Cal Poly opted to close campus as of early April and transition Spring Quarter courses to an entirely virtual format. For us, this meant ceasing all manufacturing of our spaceship, as we no longer had access to Cal Poly Machine Shops. Additionally, the RSVP performance was transitioned to a virtual platform, meaning that the show did, in fact, go on! However, this also meant that the Music Department would no longer require a spaceship prop for the performance. Unfortunately, this meant that we did not get to see our spaceship concept come to fruition.

Although we did not get to complete our project in the way that we had intended to, our team is proud of all we have learned through this process and is incredibly grateful for our ability to continue our education remotely during this troubling time. As such, we have decided to 'finish' our project by creating an online resource that encompasses all we have learned through this design process. Our hope was that anyone needing to create a prop for any theatrical production might find some relevant information within our guide. As such, we did our best to make our guide as general as possible, while still providing relevant details from our project. We chose to use 'Instructables' as our medium for making this guide. Through it, we were able to produce a 25-step process for making a theatrical prop entitled: *An Engineer's Guide to Making a Theatrical Prop.* The Instructables guide can be found using the following link:
https://www.instructables.com/id/An-Engineers-Guide-to-Making-a-Theatrical-Prop/.

9.0 Project Management

This section outlines the design process we have taken to complete the project. Our completed major milestones can be found in Table 11. The Gantt chart (Attachment P) summarizes these milestones and tasks in a schedule for the entire project.

9.1 Design Process

Following the Preliminary Design Review, we began procuring materials in order to begin testing. Foam as a mold proved to be a heavily expensive option and, having taken inspiration from design projects such as rose float, found the potential in chicken wire as a more cost-effective solution. Ordering for testing purposes also allowed us to gage the length of lead-time. The thermoplastics were the longest, taking a little less than a week to deliver.

By the Interim Design Review, some of preliminary had been conducted and both the thruster and top hatch pivot mechanisms had been designed. The CAD model at this time had been fleshed out and nearly completed.

Prior to CDR, the structural prototype for the chair mechanism was manufactured and assembled, engineering drawings were created for each subsystem, preliminary tests were performed, and funds through the Baker/Koob Endowment were secured. Additionally, a Manufacturing Plan and a Design Verification page were written for assembly and testing.

Following approval after the CDR, we began ordering materials and complete a Risk Assessment for the Safety Review. As of early March, we were in full swing of manufacturing the confirmation prototype and, on March 12th, the status of which was presented during the Manufacturing and Test Review.

Following the Manufacturing and Test Review, we began the manufacturing and assembly of the confirmation prototype. Before RSVP rehearsals, we planned on testing the confirmation prototype to ensure it meets the required specifications for a successful delivery during the show. However, as of mid-March, the scope of our project changed drastically due to the COVID-19 pandemic.

Due to the nature of this pandemic, large gatherings, such as the RSVP performance, were canceled or postponed. Additionally, Cal Poly courses became completely virtual for Spring Quarter 2020, and students no longer had access to many campus resources, including the Machine Shops. These unfortunate circumstances prompted us to become more creative with the nature of our project.

As such, the team opted to focus mainly on the creation of an open source guide for creating theater props, such as ours, as detailed in the Shift in Project Scope section. Additionally, our team aided in the transition to a completely virtual RSVP Performance. The entirety of this project culminated in our Final Design Review. The Final Design Review was completely virtual and served as an opportunity for all senior project teams to present their completed project. The entire list of completed key deliverables can be found in Table 10.

Table 10. Key Deliverable Table

Deliverable	Completion Date
Preliminary Design Review	November 11th, 2019
Critical Design Review	February 4th, 2020
Manufacturing and Test Review	March 12th, 2020
Load-in Dates*	May 15-17th, 2020
RSVP Performance*	May 26th and 28th, 2020
Final Design Review / Expo	May 29th, 2020

*No longer applicable, due to the COVID-19 pandemic.

9.2 Gantt Chart

The key deliverables define due dates, which form the foundation of the Gantt Chart. However, this chart expands upon the due dates by including the sub-tasks required to reach each milestone. Each of these tasks has an expected timeframe, dependencies on tasks that need to be completed prior, and a person or two assigned to it. It can be seen in full in Attachment N in the appendix. This chart was a living document throughout the project: we returned to it every month to add more detail as we got closer to deadlines. It should be noted that no further updates were made to the Gantt Chart after the end of March 2020 due to the COVID-19 pandemic.

10.0 Conclusion

This report demonstrates the comprehensive research conducted for this project, the ideation process, and idea selection process our team has gone through in order to develop a final design. Included are the CAD models, engineering drawings, Bill of Materials, Manufacturing Plan, and Verification Plan in order to successfully construct this spaceship if construction were to continue. *An Engineer's Guide to Making a Theatrical Prop* has allowed us to utilize the knowledge and experiences gained from this project into something that will hopefully help future students and prop developers.

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Attachment A: Sponsor Meeting Notes

Meeting with Sponsor |Minutes

October, 3rd, 2019 | 11 a.m.| Dr. Barata's Office

Type of meeting	**Sponsor Meeting**
Attendees	**Dr. Barata, Taylor Chavez, Deven Frauenhofer, Andrew Nott, Zoe Riesen, and Heavenly Body Group**
Note taker	**Zoe Riesen**

MEETING NOTES

- It is critical to understand the space for which we're designing
  - the performance will be in the pavilion
    - this performance space essentially has no backstage (all scene changes/prop deployment need to be creative and discreet)
    - this space is ideal because it provides much more intimacy between the actors and the audience
- Previous groups have successfully deployed elaborate mechanisms
  - Turntable
  - Kelp bed
- The devil is in the details
  - Size constraints: Stage height and panel width (~ 30in by 4ft)
  - bureaucratic things: theater safety
    - must pass inspection by theater department
    - using motors/electricity requires certification by Cal Poly (may be better to stay away from this option)
- Budget
  - Seek money where we can
    - Some money available, but this will be an expensive show!
      - note: it is important not to share details of this show as it is a part of the mystique
        - Example: there was a scene representing primitive humans in which a hunter comes back with a dead deer. As a sort of publicity stunt, Dr. Barata walked out of his office and down the hall with this dead deer prop in hand--its safe to say some eyebrows were raised.
- Summary of last year's show
  - A rock shredder was about to be inducted into the hall of fame

            - some of his music was sent into space by NASA
                - it turns out aliens got a hold of his music and to them, it's not music, it's medicine--it has cured one of the great plagues of their planet
    - In the beginning, it's like the audience is backstage of a talk show watching an interview with this shredder
    - At the end, you're actually watching the interview
        - the rock star reveals he's leaving
    - The show concludes with a radio saying his plane has gone missing and the audience is left unsure of what happened
- This year's show
    - There is a memorial show for this shredder
    - At the near end of the show, he returns on a spaceship!
        - Dr. Barata must be able to get into the spaceship discreetly and exit following deployment
    - this show will be EXPENSIVE
        - recreate red carpet feel before the show to celebrate the 25th (and perhaps final) year of RSVP
            - video, tux, gowns, etc.
- Themes:
    - Last year: Issues of religion
        - Shredder (represents Abraham) doesn't get into the hall of fame (represents promised land)
    - This year: call and response style (call from god?)
        - aliens = angels/people from spiritual realm
        - want audience response!!
        - attention to detail is CRITICAL!
- We then took a tour of the performance space.

Attachment B: Second Sponsor Meeting Notes

Meeting with Sponsor | Minutes

October, 15th, 2019 | 11 a.m. | Dr. Barata's Office

Type of meeting	**Sponsor Meeting**
Attendees	**Dr. Barata, Taylor Chavez, Deven Frauenhofer, Andrew Nott, and Zoe Riesen**
Note taker	**Zoe Riesen**

MEETING NOTES

- Deploy on the stage or dance floor?
  - Deploy onto the dance floor area!
    - Marley floor--material on the dancefloor (similar to the vinyl): 1/4 in rubbery material with the right amount of stick and slide for a dancer
    - usually need to get verification for castors --talk to people at the PAC
    - smoother surface for rolling, dampens the sounds (trivially)
- Past materials used?
  - No prior examples (N/A: Turntable: wood)
  - Thermoplastics sounds good! —run by Clint, may have had prior experience
  - High density foam too?
- RSVP is comprised of acting, dancing, and musical moments --this show in particular might have more musical moments
- Intermission --will view be obscured ever?
  - might be a curtain in the back?
  - maybe have a hatch on the stage? **This wouldn't be a difficult task--ask clint
- Tinted window… for spaceship
  - Audience can't see driver until he gets out! (advantageous if driver can see)
- Driver costume:
  - maybe space helmet.. otherwise traditional attire
  - maybe will have a guitar—guitar hatch!!!!
- Budget?
  - ~$1000-$2000 from music department
  - hopefully ~$2000 from CPConnect
- Frame?
  - Wood? Aluminum?
- Smoker/fogger for thruster (can buy one that is driven in control room)
- Transportation to PAC?
  - Huge doors
  - maybe walk it/drive it up

Attachment C: Third Sponsor Meeting Notes

Meeting with Sponsor | Minutes

October, 28th, 2019 | 11 a.m. | Dr. Barata's Office

Type of meeting	**Sponsor Meeting**
Attendees	**Dr. Barata, Taylor Chavez, Deven Frauenhofer, Andrew Nott, and Zoe Riesen**
Note taker	**Zoe Riesen**

MEETING NOTES

- Wings: slide out from below or fold up
- Wings fold out from over doors then doors open up
- Top of car raises up?
- Exit from side
- Outside of the box thinking: build stage higher?
  - Just one section
- No wings ? or small deployable wings/fins
  - Classic rocket s a giant pencil
  - Flatten sides of cylinder
  - Doesn't necessarily have to look like a jet
- Have to know it's a spaceship!!!
  - No visible wheels
  - Looks cool –brings in sportscar elements
  - Smooth, curved, streamlined—corvette
- Bright light inside… silhouette when pilot exits?
- No color scheme in mind
  - Clean aspect of all white lights
    - Maybe red lights ?
  - Use everything judiciously
- License plate: OAMDG appeared in every RSVP!
  - "all to the greater glory of god"

Attachment D: Engineering Librarian Interview Notes

Meeting with Engineering Librarian|Minutes

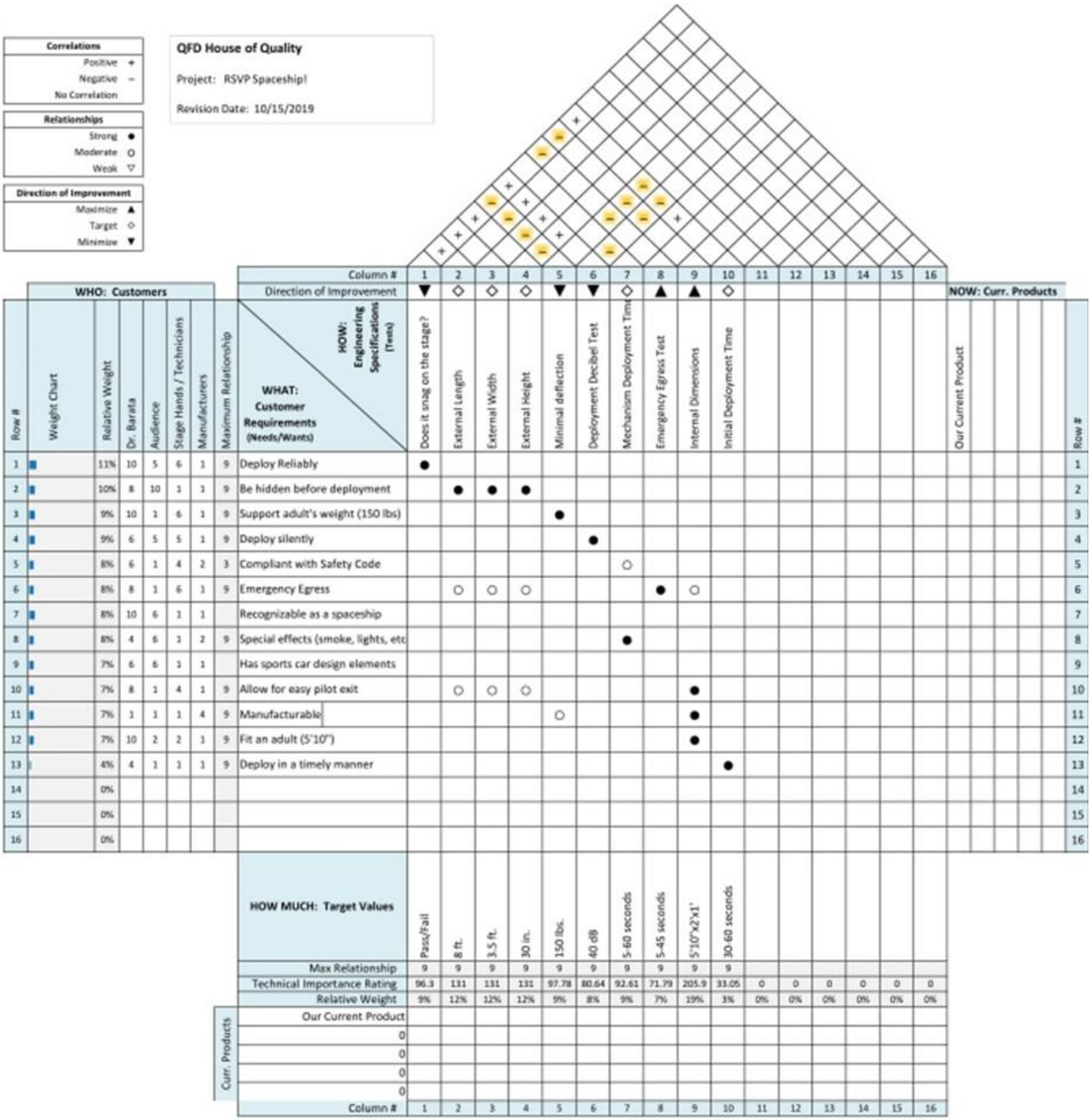
October, 15th, 2019 | noon | Kennedy Library R216D

Type of meeting	**Informational Interview**
Attendees	**Sarah Lester, Taylor Chavez, Andrew Nott, Zoe Riesen,**
Note taker	**Zoe Riesen**

MEETING NOTES

- Spaceship Research
  - Patents shouldn't be a concern…
    - Might look into Model Rocket Patents?
      - more to gather information on design elements
      - a good resource might be: the Rocketry Forum
  - Make sure our design isn't too much like someone else's--because our design is going to be used 'commercially' (people are paying to go to this performance)
    - potential trademarked design
    - potential copyright infringement
  - Might look at Jalopnik for car ideas
    - see bloodhound supersonic car
  - Theatrical props books on OneSearch!
    - The prop effects guidebook: lights, sound, motion, and magic
    - Scenic design and lighting techniques: a basic guide for theater
    - Technical design solutions for theater

Attachment E: QFD House of Quality



Correlations	
Positive	+
Negative	–
No Correlation	

Relationships	
Strong	●
Moderate	○
Weak	▽

Direction of Improvement	
Maximize	▲
Target	◇
Minimize	▼

QFD House of Quality

Project: RSVP Spaceship!

Revision Date: 10/15/2019

Row #	Relative Weight	Dr. Barata	Audience	Stage Hands / Technicians	Manufacturers	Maximum Relationship	WHAT: Customer Requirements (Needs/Wants)	1 Does it snag on the stage?	2 External Length	3 External Width	4 External Height	5 Minimal deflection	6 Deployment Decibel Test	7 Mechanism Deployment Time	8 Emergency Egress Test	9 Internal Dimensions	10 Initial Deployment Time	11	12	13	14	15	16	Our Current Product	Row #
							Direction of Improvement	▼	◇	◇	◇	▼	▼	◇	▲	▲	◇								
1	11%	10	5	6	1	9	Deploy Reliably	●																	1
2	10%	8	10	1	1	9	Be hidden before deployment		●	●	●														2
3	9%	10	1	6	1	9	Support adult's weight (150 lbs)					●													3
4	9%	6	5	5	1	9	Deploy silently						●												4
5	8%	6	1	4	2	3	Compliant with Safety Code							○											5
6	8%	8	1	6	1	9	Emergency Egress		○	○	○				●	○									6
7	8%	10	6	1	1		Recognizable as a spaceship																		7
8	8%	4	6	1	2	9	Special effects (smoke, lights, etc							●											8
9	7%	6	6	1	1		Has sports car design elements																		9
10	7%	8	1	4	1	9	Allow for easy pilot exit		○	○	○					●									10
11	7%	1	1	1	4	9	Manufacturable					○				●									11
12	7%	10	2	2	1	9	Fit an adult (5'10")									●									12
13	4%	4	1	1	1	9	Deploy in a timely manner										●								13
14	0%																								14
15	0%																								15
16	0%																								16

Column #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
HOW MUCH: Target Values	Pass/Fail	8 ft.	3.5 ft.	30 in.	150 lbs.	40 dB	5-60 seconds	5-45 seconds	5'10"x2'x1'	30-60 seconds						
Max Relationship	9	9	9	9	9	9	9	9	9	9						
Technical Importance Rating	96.3	131	131	131	97.78	80.64	92.61	71.79	205.9	33.05	0	0	0	0	0	0
Relative Weight	9%	12%	12%	12%	9%	8%	9%	7%	19%	3%	0%	0%	0%	0%	0%	0%
Curr. Products: Our Current Product																
0																
0																
0																
0																
Column #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

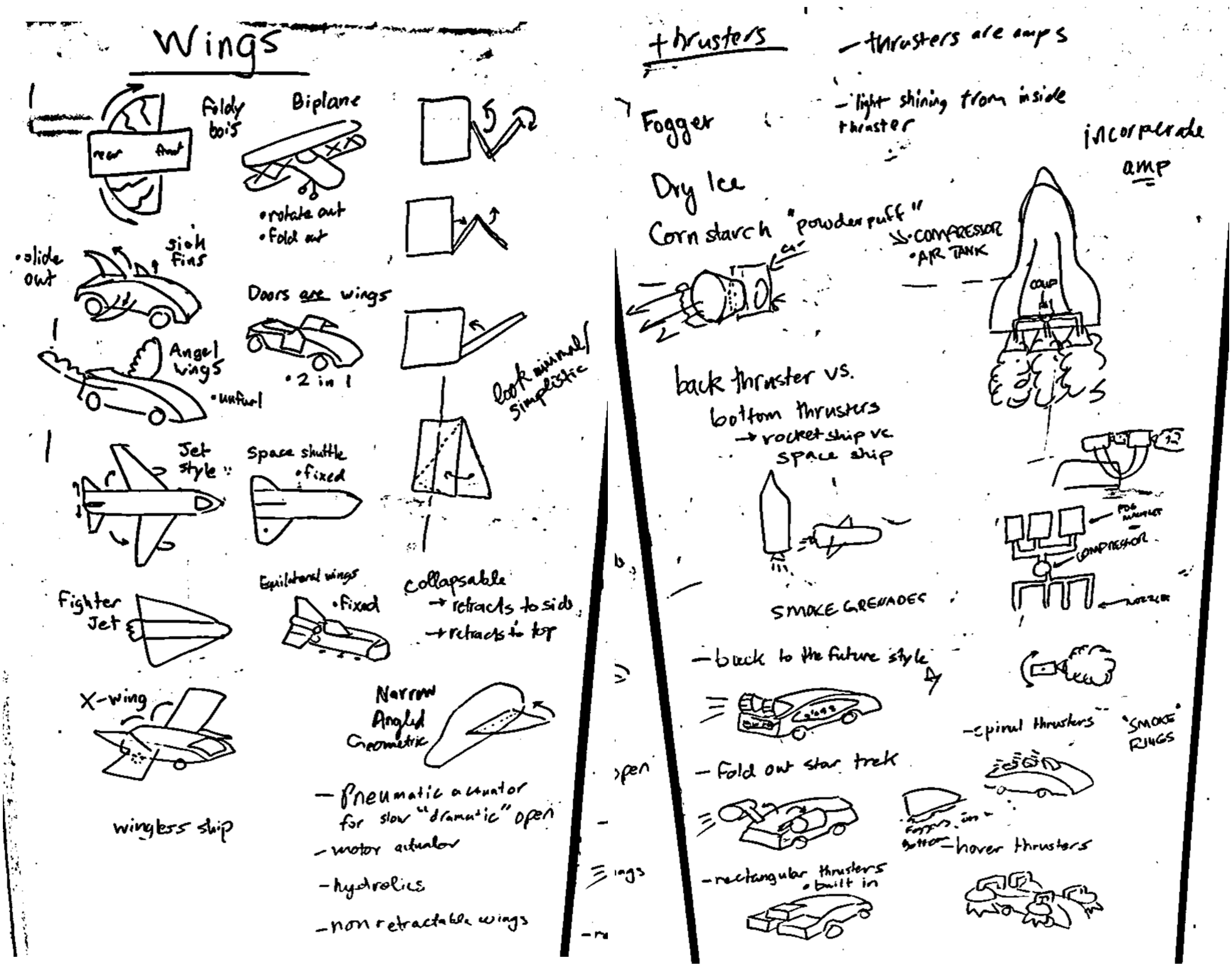
Attachment F: Sticky Note Ideation

The following ideas were generated during our sticky note ideation session for pilot exit:

- Button to get out
- Cockpit window opens
- Car is elevated/on suspension; actor descends
- Slide door opens upward
- He uses a slide
- Car transforms
- Lever to get out
- Foot pedal to get out
- Slide door opens outward
- He elevates out
- Entire ship combusts, actor rolls out
- Teleportation
- Top opens into small personal stage
- Seat slides out
- Actor is always out, like on a motorcycle (maybe helmet removal is the actual reveal)
- Raised pedestal
- Ejector seat
- Mimic sci-fi ramp
- Spaceship “falls apart” around actor
- Front opens like sideways mouth
- Is lifted out/flies
- Holographic message
- Alien abduction exit
- Transports out
- Bat mobile
- Climbs out
- Hatch opens
- Falls out
- Steps out
- Steps deploy/walks down
- Handles
- Floor, foot grooves
- Floor roller

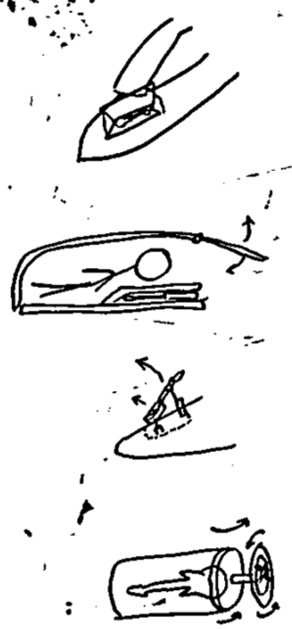
Attachment G: White Board Ideation

The following images were taken following our whiteboard ideation session on wings, thrusters, guitar, and lighting:



Guitar

- floating platform



Pop open the trunk
- secret compartment
  side hatch
- Hinges
  sliding door

- Fonzie-style open

"flies" down from sky

lifts up on pedistal

- INSIDE WING

staircase

☆ multiple guitars

- his own thrusters

Aesthetics
- lots of glass
- incorporate amps into design
  ↳ maybe thrusters

Lights

String lights — internal lighting?

light bulbs w/ casing

car lights

- Aircraft signal lights

STROBE LIGHTS blinking lights (internal / external)

HIGH-POWER, YELLOW

Colors:
red
purple
yellow

- can we get a spotlight on
☆ the door as he exits

- attached around door, cockpit, etc.

LED STREAK LINES

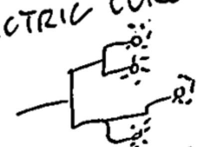
Symmetric lights

FAKE FIRE →

- Landing strip lights?

- pulsing, space-y lights

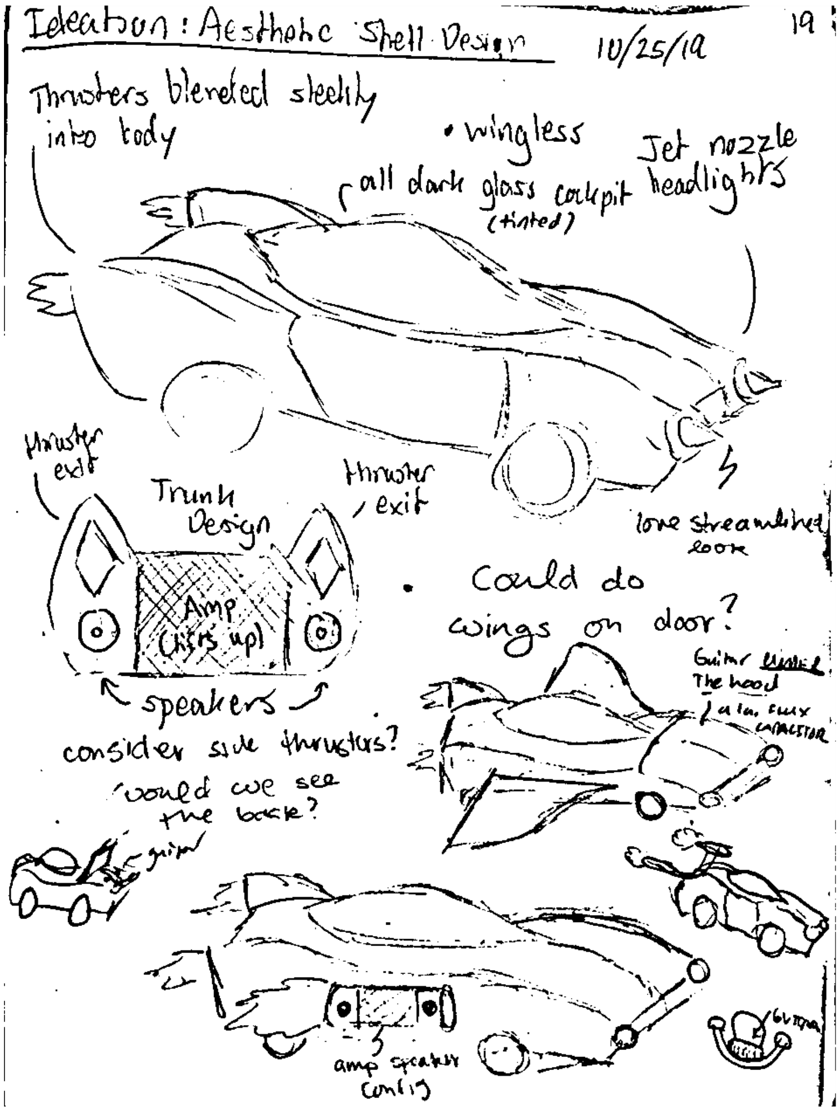
ELECTRIC CURCUIT

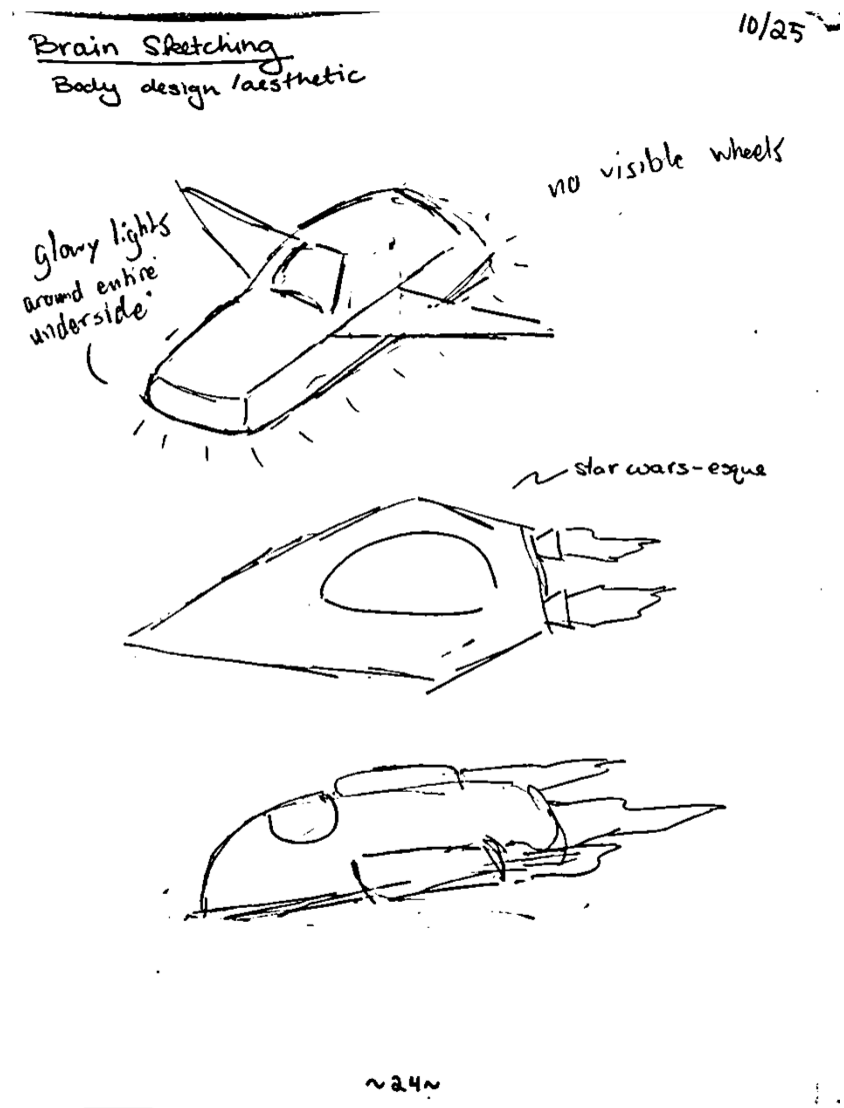


Concert lighting
sports car lighting
NEON LIGHTS

Attachment H: Brain Sketching Ideation

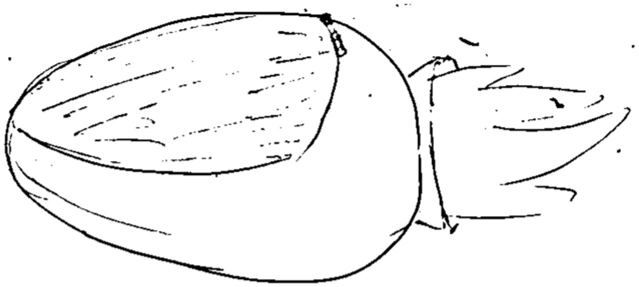
Images from our brain sketching ideation session on spacecraft body design are included below.





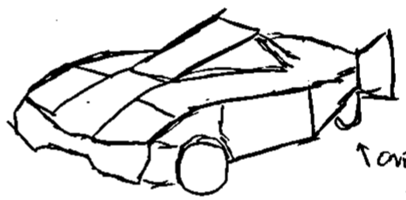
sleek egg pod

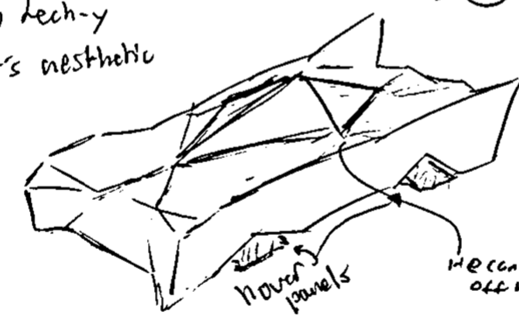
-apple aesthetic

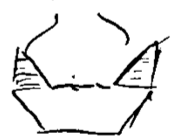


Edgy Sharp

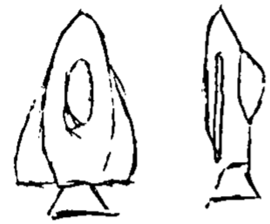
- geometric
- modern tech-y
- Razor's aesthetic

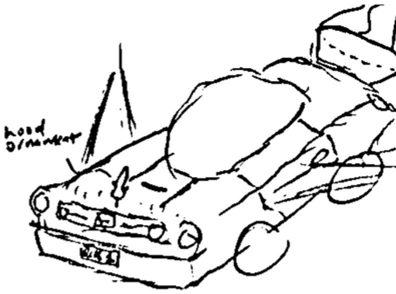






~25~

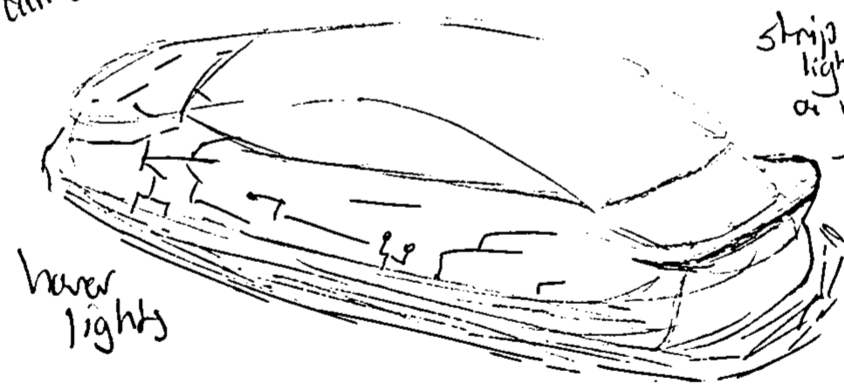


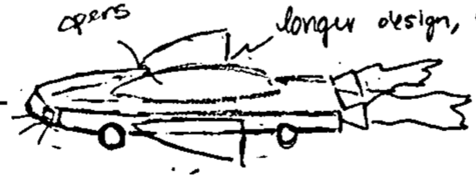


- maybe Barata has symbols we could incorporate into the prop?

circuit board skin

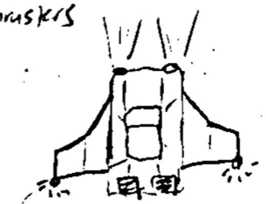
!! love this

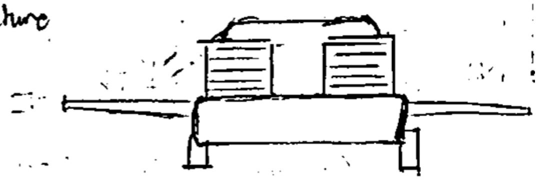


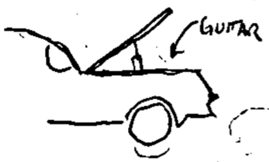


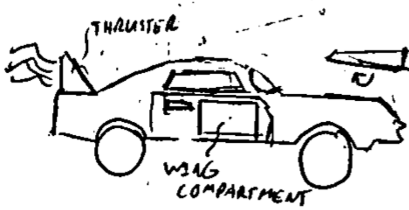
10/25/19 Car (Bram) Sketch

- Pontiac Body (Burt Reynold's, Firebird) ← Smokey & the Bandit
- Jet Wings
- Back to the Future Thrusters
- Car powers down when guitar is removed. Like the battery or key? Think flux capacitor from Back to the Future





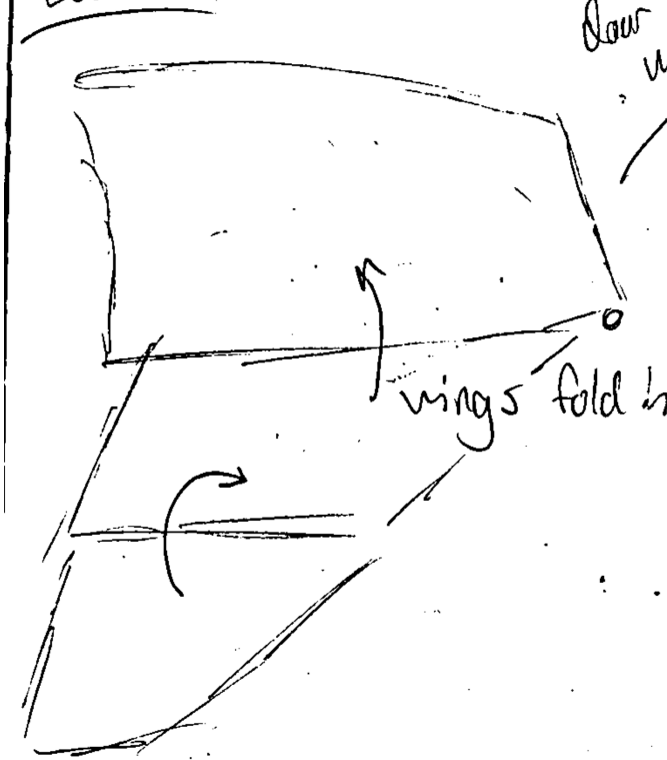


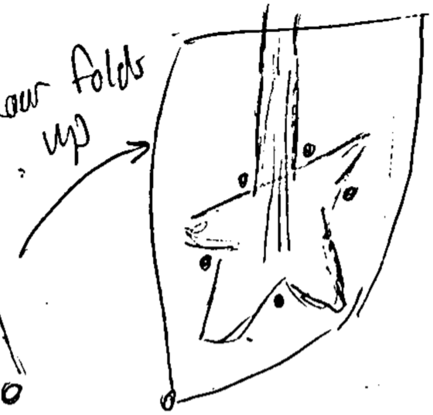


or some other rocker design on hood

21

Door





guitar stands on either wing (+ one in hood or trunk?)

Bait & switch.

Attachment I: Concept Models

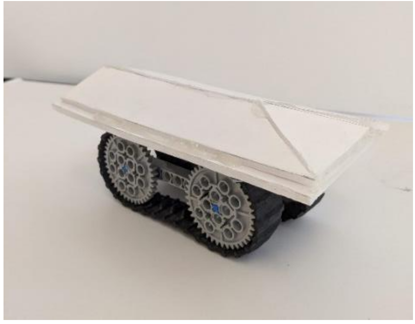


Figure 1. Tank treads.

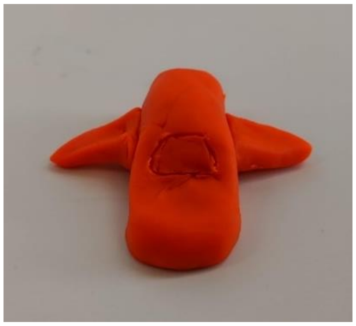


Figure 2. Play-Doh shell.

Figure 3. Play-Doh & foil hatch.

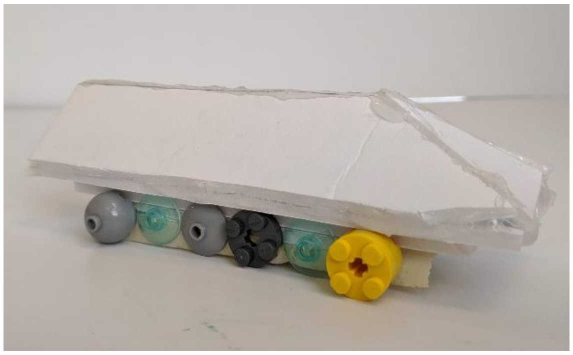


Figure 4. Train wheels.

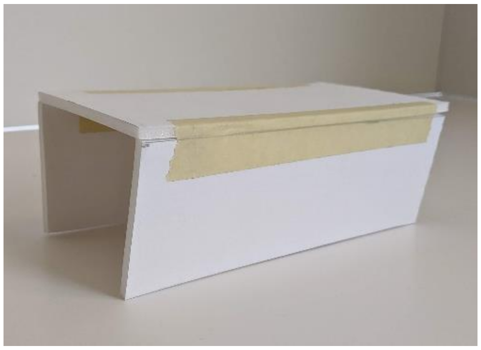


Figure 5. Scale stage section model.

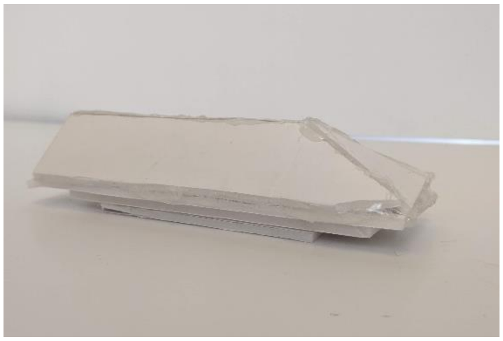


Figure 6. Sliding rail locomotion.

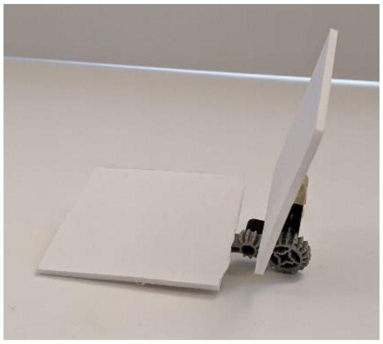


Figure 7. Pivoting wings.

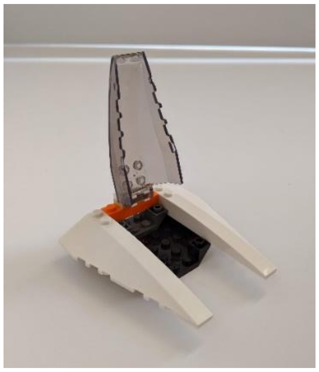


Figure 8. Lego shell and hood.

Figure 9. Guitar actuation mechanism.

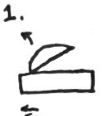
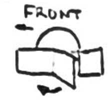
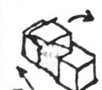
Attachment J: Pugh Matrices

The following Pugh Matrices were developed for five functions: prop locomotion, wing deployment, pilot exit, thrusters, and guitar retrieval.

4 Pugh Matrix: Prop Locomotion

Criteria \ Concepts	Car Wheels	Rails	Roller Skates	Tank Treads	Castors	Tricycle Δ	Tricycle ∇	Bike with training wheels
Reliability	D	+	+	+	0	0	0	−
Noise Level		+	−	−	0	0	0	0
Space	A	+	+	−	+	+	+	+
Friction		−	0	−	+	+	+	+
Aesthetics	T	+	+	−	+	0	0	0
Budget		0	−	−	+	+	+	+
Manufacturable	U	0	−	−	+	+	+	+
Stability		0	+	+	0	0	0	−
Total	M	3	1	-4	5	4	4	2
					★	★		

Criteria \ Concept:	1. Simple Fixed Wings	2. Fighter Jet Fixed Wings	3. Foldable Wings	4. Slide out wings (bottom)	5. Door as wings	6. Spiral wings	7. Nowm
Aesthetic	D	S	S	S	+	S	−
Space	a	+	+	+	+	−	+
Ease of Deployment	t	S	−	−	S	S	+
Reliability	u	S	−	−	S	S	+
"Wow" factor	m	S	+	+	S	S	−
Manufacturability		S	−	−	S	S	+
Budget		S	−	−	S	S	+
Compatability w/ design		S	S	S	S	S	−
Pilot exit		S	+	+	+	S	+
Total:	0	1	-1	-1	3 ★	-1	3 ★

CONCEPT / CRITERIA	1.  FRONT	2.  FRONT	3.  FRONT	4. FRONT 	5.  FRONT	6. FRONT 	7. FRONT 	8.  FRONT
EASE OF ENTRANCE/EXIT ON STAGE		S	S	+	+	−	−	+
EASE OF ENTRANCE/EXIT UNDER STAGE		−	+	+	S	+	+	+
ACTION IS INTERESTING		S	S	−	+	−	−	S
VERSITILITY W/GUITAR		S	S	−	S	+	+	−
VERSITILITY W/WINGS		S	−	−	S	S	S	−
VERSITILITY W/LIGHTS		S	S	S	S	S	S	S
VERSITILITY W/THRUSTERS		S	S	S	S	−	−	−
RELIABILITY		S	S	+	−	+	+	S
COMPACTNESS		S	+	+	S	+	+	+
MANUFACTUREABILITY		S	S	+	−	+	+	−
SPEED		S	+	+	−	+	+	S
VERSITILITY W/METHODS OF EXIT		+	−	−	S	−	−	−
SYMMETRY		S	−	−	−	S	S	−
Σ +		1	3	6	2	6	6	3
Σ −		1	3	5	4	4	4	6
Σ TOT		0	0	1	−2	2	2	−3

10/31/19

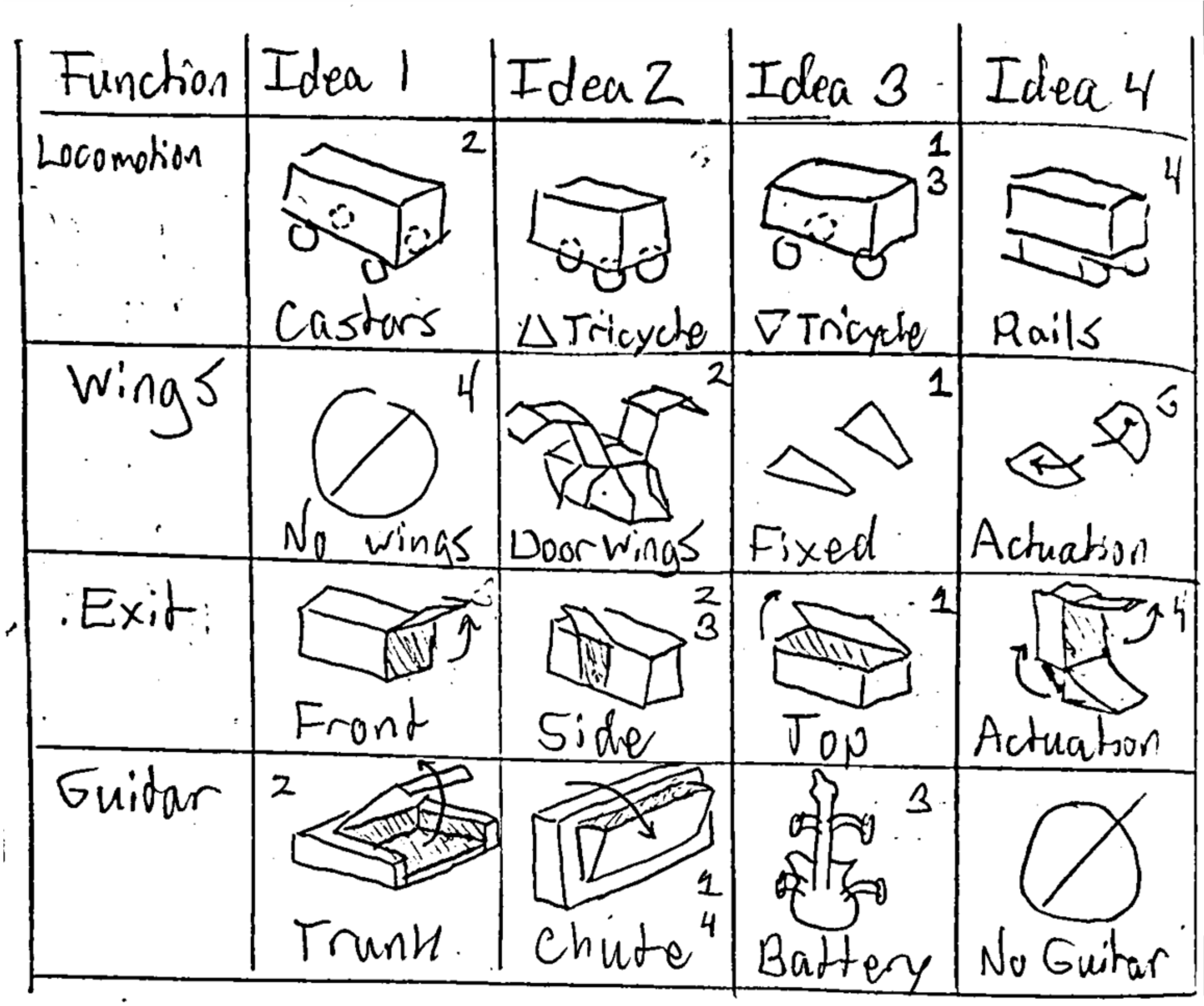
Concept / Criteria	1	TRUNKVAULT DATUM	Guitar Powers ship 2	Guitar pursot wing 3	No guitar 4
Budget	0	0	-	-	+
Manufacturability	0	0	-	-	+
Space	+	0	-	-	+
Aesthetic/Appeal	0	0	+	+	-
Deployability	0	0	-	-	+
Totals	-1	~	-3	-3	3

Pugh Matrix: Guitar Retrieval

Concept / Criteria	Back to the future Datum	1	Built in rectangular thrusters 2	One big Thruster 3	spinal thruster 4	No thruster 5
Budget	0	-	0	+	-	+
Space	0	-	0	0	-	+
Aesthetic/Appeal	0	+	0	-	+	-
Deployability	0	-	0	0	0	+
Manufacturability	0	-	0	+	-	+
Totals	0	-3	0	1	-2	3

Pugh Matrix: Thrusters

Attachment K: Morphological Matrix



Function	Idea 1	Idea 2	Idea 3	Idea 4
Locomotion	2 Castors	△Tricycle	1 3 ∇Tricycle	4 Rails
Wings	4 No wings	2 Door Wings	1 Fixed	3 Actuation
Exit	3 Front	2 3 Side	1 Top	4 Actuation
Guitar	2 Trunk	1 4 Chute	3 Battery	No Guitar

Resultant Idea Combinations

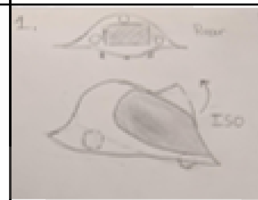
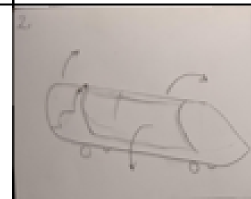
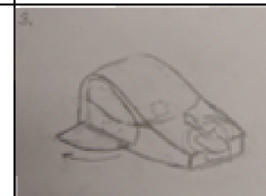
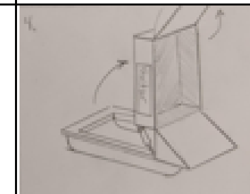
1: fixed wing tricycle with a chute and top exit.

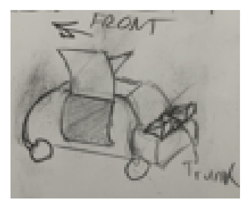
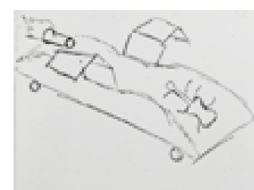
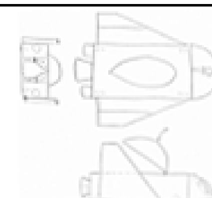
2: side door wings with 4 castors & a trunk

3: Guitar powered tricycle with actuating wings & side exit

4: Actuating exit with rails, no wings, and a chute.

Attachment L: Weighted Decision Matrix

Team 33: RSVP Space Ship. Scale: 1-5	11/5/2019	**Idea 1**	**Idea 2**	**Idea 3**	**Idea 4**
Specification	**Weight**				
Deploy Reliably	4	4	4	3	1
Cost	2	5	5	4	3
Support adult's weight (150 lbs)	1	4	4	4	2
Compliant with Spacing	4	3	5	4	5
Emergency Egress	2	2	4	5	3.5
Recognizable as a spaceship	4	5	2	3	2
Special effects (smoke, lights, etc.)	2	3.5	1	2	5
Has sports car design elements	1	1	1	2	3.5
Allow for easy pilot exit	4	3.5	3	4	5
Manufacturable	3	4.5	5	4	2
Total	**135**	**101.5**	**96**	**96**	**86.5**

Team 33: RSVP Space Ship. Scale: 1-5	11/5/2019	**Idea 5**	**Idea 6**	**Idea 7**	**Idea 8**
Specification	**Weight**				
Deploy Reliably	4	4	3	3	2.5
Cost	2	3	4	4	2.5
Support adult's weight (150 lbs)	1	4	4	4	4
Compliant with Spacing	4	4	3.5	4.5	4
Emergency Egress	2	5	4	4	5
Recognizable as a spaceship	4	3	2	3	5
Special effects (smoke, lights, etc.)	2	3.25	2.5	3	4
Has sports car design elements	1	5	5	5	3
Allow for easy pilot exit	4	5	5	5	2
Manufacturable	3	4	3.5	3.5	3
Total	**135**	**107.5**	**94.5**	**103.5**	**93**

Attachment M: Design Hazard Checklist

Y	N	
●		1. Will any part of the design create hazardous revolving, reciprocating, running, shearing, punching, pressing, squeezing, drawing, cutting, rolling, mixing or similar action, including pinch points and sheer points?
	●	2. Can any part of the design undergo high accelerations/decelerations?
	●	3. Will the system have any large moving masses or large forces?
	●	4. Will the system produce a projectile?
	●	5. Would it be possible for the system to fall under gravity creating injury?
	●	6. Will a user be exposed to overhanging weights as part of the design?
	●	7. Will the system have any sharp edges?
	●	8. Will any part of the electrical systems not be grounded?
	●	9. Will there be any large batteries or electrical voltage in the system above 40 V?
	●	10. Will there be any stored energy in the system such as batteries, flywheels, hanging weights or pressurized fluids?
	●	11. Will there be any explosive or flammable liquids, gases, or dust fuel as part of the system?
●		12. Will the user of the design be required to exert any abnormal effort or physical posture during the use of the design?
	●	13. Will there be any materials known to be hazardous to humans involved in either the design or the manufacturing of the design?
	●	14. Can the system generate high levels of noise?
	●	15. Will the device/system be exposed to extreme environmental conditions such as fog, humidity, cold, high temperatures, etc.?
	●	16. Is it possible for the system to be used in an unsafe manner?
	●	17. Will there be any other potential hazards not listed above? If yes, please explain on reverse.

For any “Y” responses, on the reverse side add:

(1) a complete description of the hazard,
(2) the corrective action(s) you plan to take to protect the user, and
(3) a date by which the planned actions will be completed.

Hazard #	Description of Hazard	Planned Corrective Action	Planned Date	Actual Date
1.	Potential pinch points when opening door.	Padding around pinch points with testing/rehearsal to verify safety.	April 2020	
12.	Pilot must get into/out of vessel, as well as stay in confined space for an extended period of time.	Prototyping effective chair mechanism as well as designing for ease of entrance. Designing/manufacturing for as much comfort as possible within the confined space.	November 2019-March 2020	

Attachment N: Indented Bill of Materials

Part Number	Assembly Level	Complexity				Total Cost
		Lvl 0	Lvl 1	Lvl 2	Lvl 3	
10000	0	Final Assembly				
11000	1		Pilot Seat			**$38.57**
11110	2			Seat Base		
11120	3			Back Rest		
12000	1		Spaceship			**$630.20**
12100	2			Fuselage		
12110	3				Nose Cone	
12120	3				Wing Frame	
12130	3				Wing Structure	
12140	3				Wing Base	
12150	3				Fuselage Shell	
12200	2			Top Hatch		
12210	3				Top Hatch Frame	
12220	3				Thermoplastic Window	
12300	2			Thrusters		
12310	3				Rear Hatch	
12320	3				Piping	
12400	2			Hood		
12410	3				Thermoplastic Hood	
12420	3				Frame	
13000	1		General Parts			**$442.02**
13100	2			Fasteners		
13110	3				Assorted Wood screws	
13120	3				Brackets	
13200	2			Off-the-Shelf Parts		
13210	3				Wheels	
13220	3				Latches	
13230	3				Pistons	
13240	3				Hinges	
13250	3				Padding	
13260	3				Guitar Case	
13270	3				Fog Machine	
13300	2			Paint and Decor		
13310	3				Window Tint	
13320	3				Thruster Shapes	
13330	3				Spray Paint (for body)	
13340	3				Lights	
14450	3				Other	
N/A		Testing				**$132.60**
					Total Cost:	**$1,243.39**

Test Materials Budget				
Material	**Vendor**	**Cost**	**Purchased?**	**Method**
Thermoplastic Sample	Home Depot	$49.00	12/3/19	Team/reimbursed
Glass Tint Sample	Home Depot	$11.09	12/3/19	Team/reimbursed
Soft Tread Castors	Home Depot	$12.91	12/3/19	Team/reimbursed
Chicken Wire Mesh (hex)	Home Depot	$15.07	1/8/20	Team/reimbursed
Chicken Wire Mesh (1/4in sq.)	Home Depot	$14.00	1/8/20	Team/reimbursed
Cotton Batting	Beverly's	$7.53	1/23/20	Team/reimbursed
Clear Thermoplastic Sample	Amazon	$23.00	2/11/20	Team/reimbursed
	Total Anticipated Cost:	**$132.60**		

Pilot Seat (Pt#11000) Budget										
Material	**Required for Part Number(s)**	**Quantity to Purchase**	**Vendor**	**Vendor Part Number**	**Cost per Unit**	**Anticipated Cost**	**Purchased?**	**Method**	**In Inventory?**	**In Assembly?**
2x4" Wood	11111, 11112, 11113, 11121, 11122	2	Home Depot	161640	$2.97	$5.94	1/20/20	Team/reimbursed	1/20/20	Yes
2x2" Wood	11114, 11115	2	Home Depot	75800593	$2.28	$4.56	1/20/20	Team/reimbursed	1/20/20	Yes
1/4" MDF	11116, 11117, 11123	2	Home Depot	1508104	$7.49	$14.98	1/20/20	Team/reimbursed	1/20/20	Yes
					Total Anticipated Cost:	**$25.48**				
					Total Spent:	**$38.57**				
					Remaining Cost:	**$0.00**				
					Total Actual Cost:	**$38.57**				

Spaceship (Pt#12000) Budget											
Material	**Required for Part Number(s)**	**Quantity to Purchase**	**Vendor**	**Vendor Part Number**	**Cost per Unit**	**Anticipated Cost**	**Purchased?**	**Method**	**In Inventory?**	**In Assembly?**	**Notes**
1x1" Square Wood Dowel	12112, 12113, 12114, 12121, 12122, 12123, 12124, 12125, 12126, 12127, 12128, 12211, 12212	23	Home Depot	IM8316U-8	$3.42	$78.66	2/18/20	Team/reimbursed	2/18/20	No	
1/4" MDF	12111, 12115, 12116, 12129, 121210, 121211, 121212, 12213, 12311	3	Home Depot	1508104	$7.49	$22.47	2/18/20	Team/reimbursed	2/18/20	No	
Mesh Thermoplastic	12131, 12410	4	Worbla	WOMA1	$76.00	$304.00	2/11/20	Pro Card	2/18/20	No	
Clear Thermoplastic	12221	3	Worbla	WOTA1	$83.00	$249.00	2/11/20	Pro Card	2/18/20	No	
Chicken Wire	12132, 12222	5	Home Depot	308234EB	$19.93	$99.65	2/18/20	Pro Card	Yes	No	
Cotton Batting	12223	4			Estimate	$20.00	No		No	No	
PVC Pipe	12321	1			Estimate	$10.00	No		No	No	
Flex Pipe	12322	2			Estimate	$10.00	No		No	No	
Aluminum Strips	12214, 12215, 12420	14	Home Depot			$20.00	No		No	No	Samples bought for testing
					Total Anticipated Cost:	**$813.78**					
					Total Spent:	**$630.20**					
					Remaining Cost:	**N/A**					
					Total Actual Cost:	**$630.20**					

General Parts (Pt#13000) Budget												
Material	Required for Part Number(s)	Quantity to Purchase	Vendor	Vendor Part Number	Cost per Unit	Anticipated Cost	Purchased?	Method	In Inventory?	In Assembly?	Notes
Assorted Wood Screws	13111	1	Home Depot	803214	$7.20	$7.20	1/20/20	Team/reimbursed	1/20/20	Yes	
3 in Wood Screws	13112	1	Home Depot	PTN3S1	$5.97	$5.97	1/20/20	Team/reimbursed	1/20/20	Yes	
U-Bracket	13121	8	Plan to use extra tie plates	N/A	$0.00	$0.00	2/18/20	Pro Card	No	No	Testing with Tie Plate
L Bracket	13122	12	Home Depot	20754	$1.77	$21.24	1/27/20	Team/reimbursed	1/27/20	Yes	
L Bracket (small)	13123	20	Home Depot	13619	$2.45	$49.00	2/18/20	Pro Card	2/19/20	No	
Corner Bracket	13124	6	Home Depot	15442	$2.41	$14.46	1/27/20	Team/reimbursed	1/27/20	Yes	
Bracket for Gas Spring	13125	8	Home Depot	8265WQ	$5.13	$41.04	2/18/20	Pro Card	3/3/20	No	
Tie Plate	13126	15	Home Depot	TP15	$0.56	$8.40	2/18/20	Pro Card	2/25/20	No	
Castors (chair)	13211	4	Amazon	711811091216	$3.25	$12.99	1/23/20	Team/reimbursed	1/23/20	Yes	
Castors (spaceship)	13212	8	Amazon	711811091216	$3.25	$26.00	2/27/20	Pro Card	3/3/20	No	
Gate Latch	13221	1	Home Depot	18109	$14.20	$14.20	2/18/20	Pro Card	2/25/20	No	
Magnetic Latch	13222	1	Home Depot	9235969	$1.98	$1.98	2/18/20	Pro Card	2/19/20	No	
Hook and Staple	13223	1	Home Depot	19754	$3.88	$3.88	2/18/20	Pro Card	2/25/20	No	
Gas Strut (17 in)	13231	2	Home Depot	3815LHA	$19.99	$39.98	2/18/20	Pro Card	3/3/20	No	
Gas Strut (23 in)	13232	2	Home Depot	3287NQA	$24.99	$49.98	2/18/20	Pro Card	3/3/20	No	
Spring Loaded Hinge	13241	4	Amazon	B07NYN9FNQ	$2.18	$8.72	1/27/20	Team/reimbursed	1/27/20	Yes	
Utility Hinge	13242	2	Home Depot	15397	$2.68	$5.36	2/18/20	Pro Card	2/25/20	No	
Padding	13250	2	Quality Fabric and Foam Supply Co.		$5.97	$11.94	No		No	No	
Guitar Case	13260	1	Quality Fabric and Foam Supply Co.		$149.00	$149.00	No		No	No	
Fog Machine	13270	1	From Dr. Barata	N/A	$0.00	$0.00	N/A	N/A	2/27/20	No	
Tint	13310	3			Estimate	$60.00	No		No	No	Spray paint or film?
Shapes for Thrusters	13320	2			Estimate	$30.00	No		No	No	Options found
Spray Paint	13330	N/A			Estimate	$50.00	No		No	No	
Lights	13340	N/A			Estimate	$50.00	No		No	No	
Other	13350	N/A			Estimate	$100.00	No		No	No	
					Total Cost:	**$761.34**					
					Total Spent:	**$442.02**					
					Remaining Cost:	**N/A**					
					Total Actual Cost:	**$442.02**					

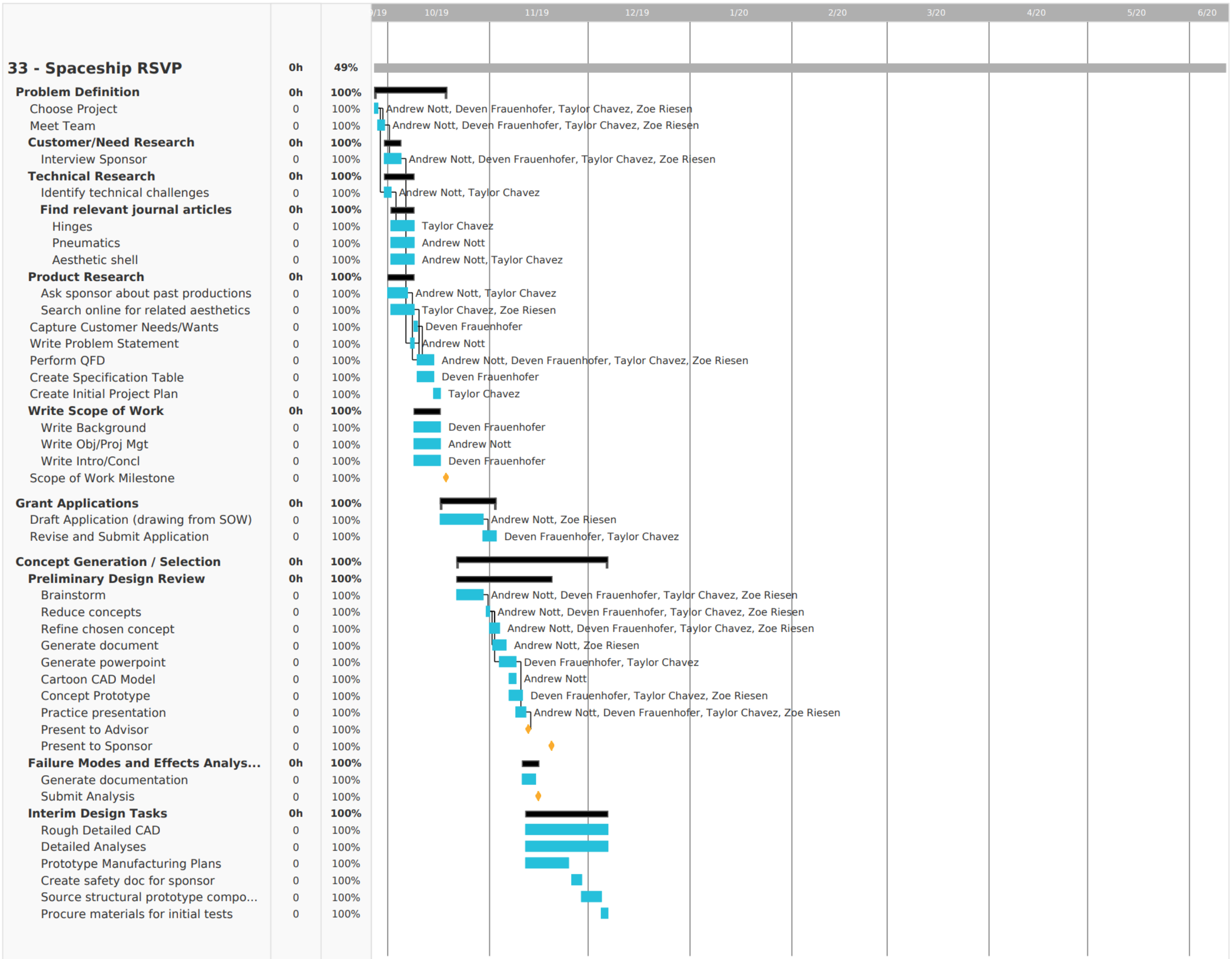
Attachment O: Design Verification Plan

Senior Project DVP&R

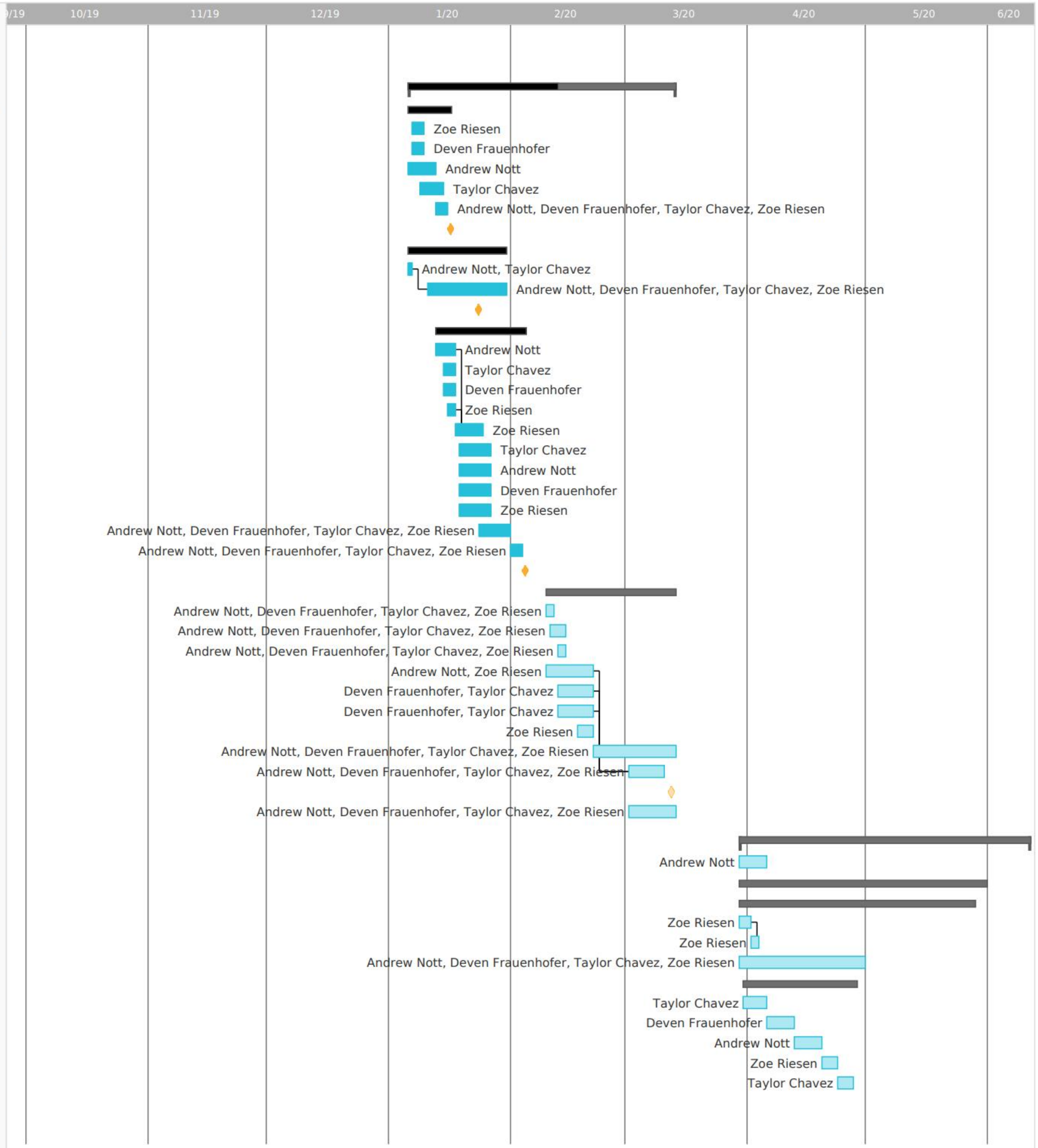
Date: 01/31/20	Team: RSVP Spaceship	Sponsor: Dr. Barata	Description of System: Deployable spaceship prop that will fit beneath 2 stage panels (4'x16'x3')	DVP&R Engineer: Zoe

TEST PLAN										TEST REPORT			
Item No	Specification #	Test Description	Acceptance Criteria	Test Responsibility	Test Stage	SAMPLES		TIMING		TEST RESULTS			NOTES
						Quantity	Type	Start date	Finish date	Test Result	Quantity Pass	Quantity Fail	
1	1	Push the prop under a stage section (4'x16'x3')	Clears stage (16 ft.)	Andrew	FP	1	Sys	4/21/2020	5/1/2020				
2	2	Push the prop under a stage section (4'x16'x3')	Clears stage (3.5 ft.)	Andrew	FP	1	Sys	4/21/2020	5/1/2020				
3	3	Push the prop under a stage section (4'x16'x3')	Clears stage (30 in.)	Andrew	FP	1	Sys	4/21/2020	5/1/2020				
4	4	Pilot will verify he sits comforatbly in chair	Pass/Fail	Deven	SP	1	Sub	2/11/2020	2/21/2020				
5	5	Measure height before and after load	1 in for 150 lb. load	Deven	SP	1	Sub	2/11/2020	2/21/2020				
6	6	Collect sound data from 5 feet away from deployment site	Maximum 40 dB	Deven	FP	1	Sys	5/1/2020	5/14/2020				
7	7	Timer set while mechanisms are deployed	60 s	Zoe	FP	1	Sys	5/1/2020	5/14/2020				
8	8	Timer set during deployment sequence	45 s	Zoe	FP	1	Sys	4/21/2020	5/14/2020				
9	9	Timer set while pilot exits prop while under stage	40 s	Zoe	FP	1	Sys	4/21/2020	5/14/2020				
10	10	Deploy prop from under stage and visually inspect snag	No snag	Taylor	FP	1	Sys	4/21/2020	5/14/2020				
11	11	Verify the thermoplastics produce a smoth surface finish through testing on small samples	Pass/Fail	Taylor	SP	1	C	Jan. 2020	Feb. 2020				
12	12	Determine roof deflection (thermoplastic deflection) for incrimental loads	1 in for 20 lb load	Taylor	FP	1	Sys	4/21/2020	5/14/2020				

Attachment P: Gantt Chart



2nd Quarter	**0h**	**56%**
Interim Design Review	**0h**	**100%**
Design Thruster Mechanism	0	100%
Design Top Hatch Pivot Mechanism	0	100%
Finish detailed design CAD	0	100%
Conduct Preliminary Tests	0	100%
Practice presentation	0	100%
Present	0	100%
Structural Prototype	**0h**	**100%**
Purchase materials	0	100%
Manufacture prototype	0	100%
Complete prototype	0	100%
Critical Design Review	**0h**	**100%**
Finish CAD to nuts-and-bolts level	0	100%
Document Preliminary Tests	0	100%
Create Design Verification Guide	0	100%
Source final design components	0	100%
Create Detailed Budget	0	100%
Update old PDR Document Sections	0	100%
Create "Final Design" Report Secti...	0	100%
Create "Manufacturing Plan" Secti...	0	100%
Create "Design Verification" Section	0	100%
Generate powerpoint	0	100%
Practice presentation	0	100%
Present	0	100%
Manufacturing and Test Review	**0h**	**0%**
Perform Risk Assessment of Design	0	0%
Develop Safety Plan	0	0%
Review Safety Plan with Shop Techs	0	0%
Order/Source Parts	0	0%
Test 4: Pilot sits comfortably in pilo...	0	0%
Test 5: Pilot seat deflection	0	0%
Expirmental Design/DVP	0	0%
Begin manufacturing verification p...	0	0%
Prepare for Manufacturing and Test...	0	0%
Present	0	0%
Draft Project Update Memo for Spo...	0	0%
3rd Quarter	**0h**	**0%**
Operators' Manual	0	0%
Final Design Review	**0h**	**0%**
Confirmation Prototype	**0h**	**0%**
Update bill of materials	0	0%
Purchase any additional materials	0	0%
Continue Manufacturing	0	0%
Verification Prototype Sign O...	**0h**	**0%**
FMEA	0	0%
Design Hazard Checklist	0	0%
Risk Assessment	0	0%
Design Verification Plan	0	0%
Test Procedures	0	0%



Present	0	0%
Testing	**0h**	**0%**
Test 1-3: External dimensions	0	0%
Test 6: Collect sound data	0	0%
Test 7&8: Time deployment se...	0	0%
Test 9: Time emergency egress	0	0%
Test 10: Snag test	0	0%
Test 12: Roof Deflection	0	0%
Complete confirmation prototype	0	0%
Load-in Dates for Performance	0	0%
RSVP Performance	0	0%
FDR Report	0	0%
Project Expo Poster Presentation	0	0%
Draft Baker Koob Final Report	0	0%
Finishing up	**0h**	**0%**
Submit final report to library	0	0%
Submit Baker Koob final report	0	0%
Return any borrowed equipment	0	0%
Clean up work areas	0	0%
Complete project completion check...	0	0%

Attachment Q: Team Contact Information

Team Email Address

rsvprocketengineers@gmail.com

Individual Contact Information

Taylor Chavez

email: tayloranthonychavez@yahoo.com

Deven Frauenhofer

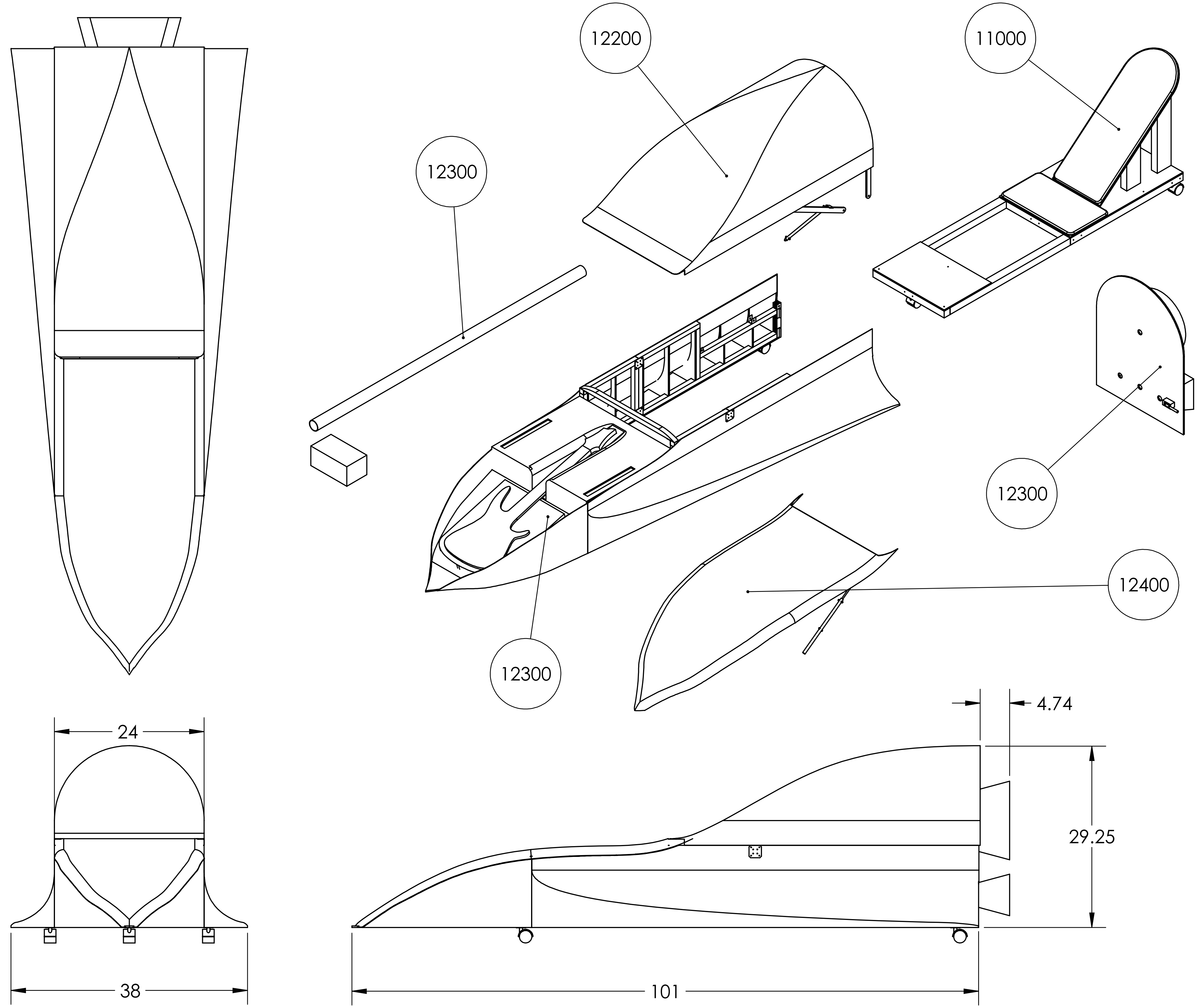
email: dfrauenh@calpoly.edu

Andrew Nott

email: adnott@calpoly.edu

Zoe Riesen

email: zriesen@calpoly.edu



NOTES
UNLESS OTHERWISE SPECIFIED
1. ALL DIMENSIONS IN INCHES
2. TOLERANCES:
X = ±.1
X.X = ±.05
X.XX = ±.01
ANGLES = ±2°

PART #	SUBASSEMBLY	QTY
11000	Pilot Seat Assembly	1
12300	Fuselage	1
12200	Top Hatch	1
12300	Thrusters	1
12400	Hood	1

Cal Poly Mechanical Engineering	Senior Project	Part #10000	Title: Overall Assembly		Drawn by: Andrew Nott
ME 428/429/430	RSVP Spaceship	Revision: 1.0	Date: 01/28/20	Scale: 1:18	Checked by: Taylor Chavez

NOTES
UNLESS OTHERWISE SPECIFIED
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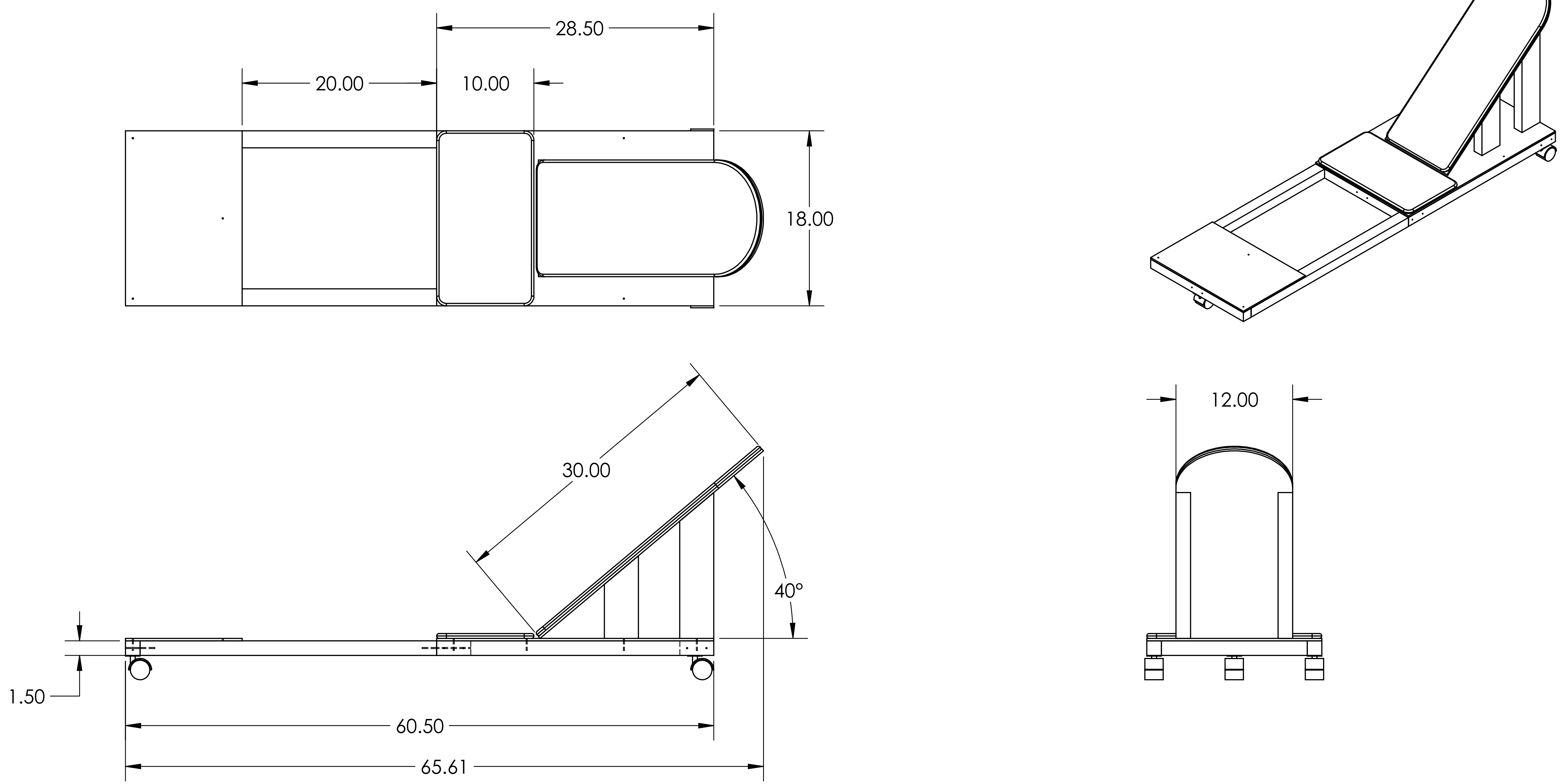
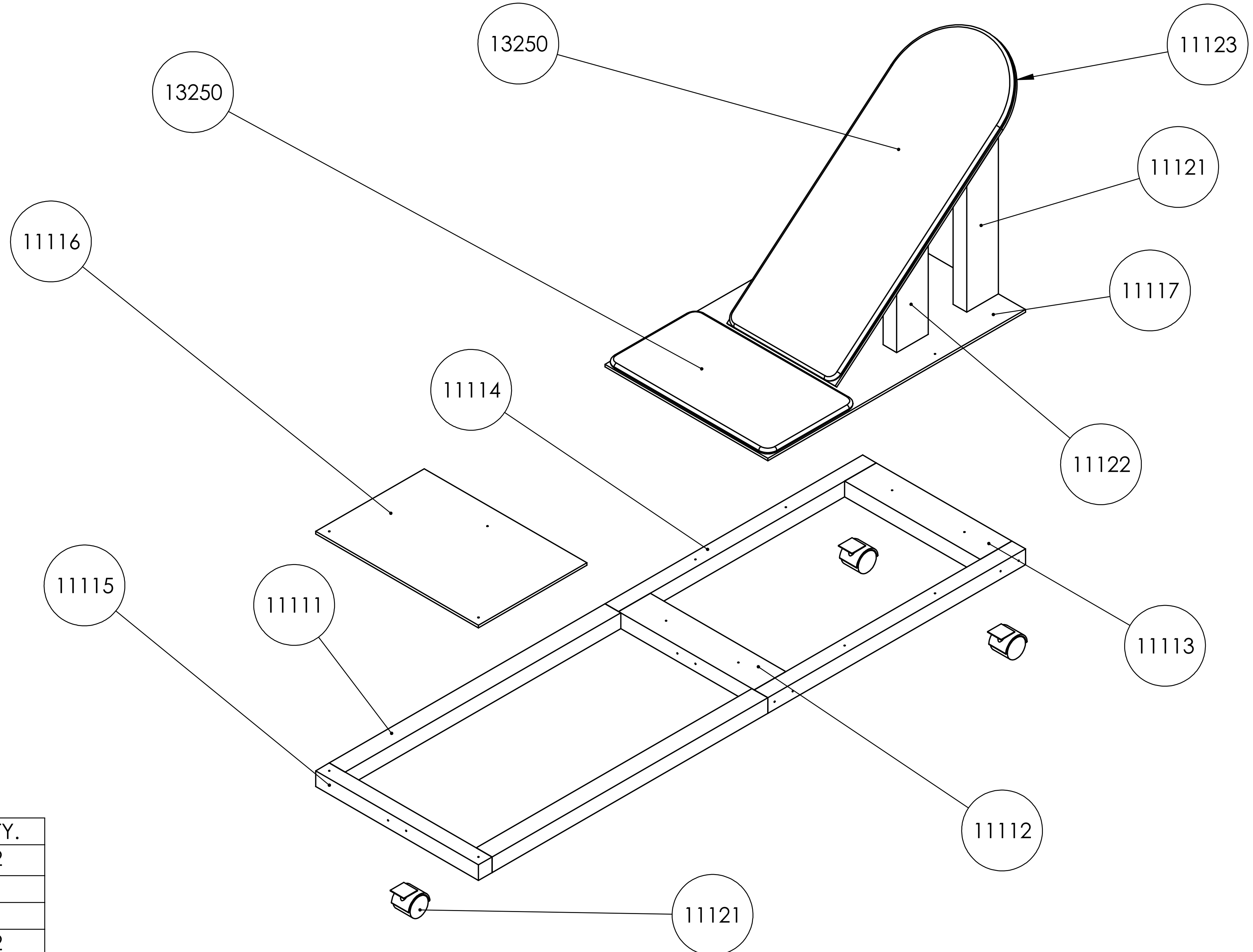
2. TOLERANCES:
X = ±.1
X.X = ±.05
X.XX = ±.01
ANGLES = ±2°

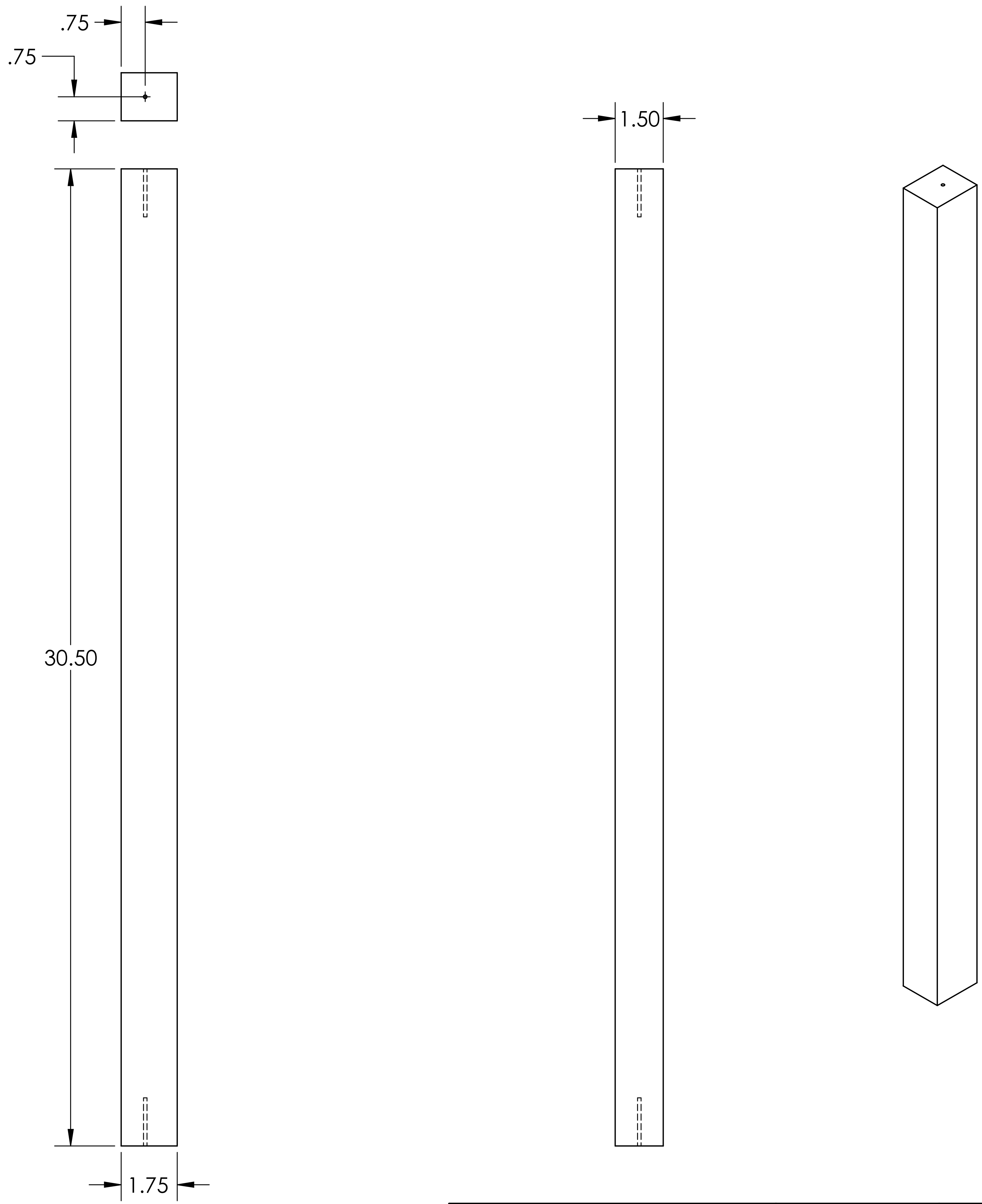


Cal Poly Mechanical Engineering	Senior Project	Part #11000	Title: Pilot Seat Assembly	Drawn by: Andrew Nott
ME 428/429/430	RSVP Spaceship	Revision: 1.0	Date: 01/28/20 · Scale: 1:12	Checked by: Taylor Chavez



ITEM NO.	PART NUMBER	/MATERIAL	QTY.
11111	Footrest Side Beam	2x2 Square Dowel Rod	2
11112	Seat Center Crossbeam	2x4 Wood	1
11113	Seat Rear Crossbeam	2x4 Wood	1
11114	Seat Side Beams	2x2 Square Dowel Rod	2
11115	Footrest Beam	2x2 Square Dowel Rod	1
11116	Footrest Cover	1/4" MDF	1
11117	Seat Bottom Cover	1/4" MDF	1
11121	Tall Back Rest Support	2x4 Wood	2
11122	Short Back Rest Support	2x4 Wood	2
11123	Back Rest	1/4" MDF	1
13250	Seat Bottom Padding	Foam	1
13250	Back Rest Padding	Foam	1

Cal Poly Mechanical Engineering	Senior Project	Part #11000	Title: Pilot Seat Assembly	Drawn by: Andrew Nott
ME 428/429/430	RSVP Spaceship	Revision: 1.0	Date: 01/28/20 · Scale: 1:10	Checked by: Taylor Chavez



NOTES

UNLESS OTHERWISE SPECIFIED

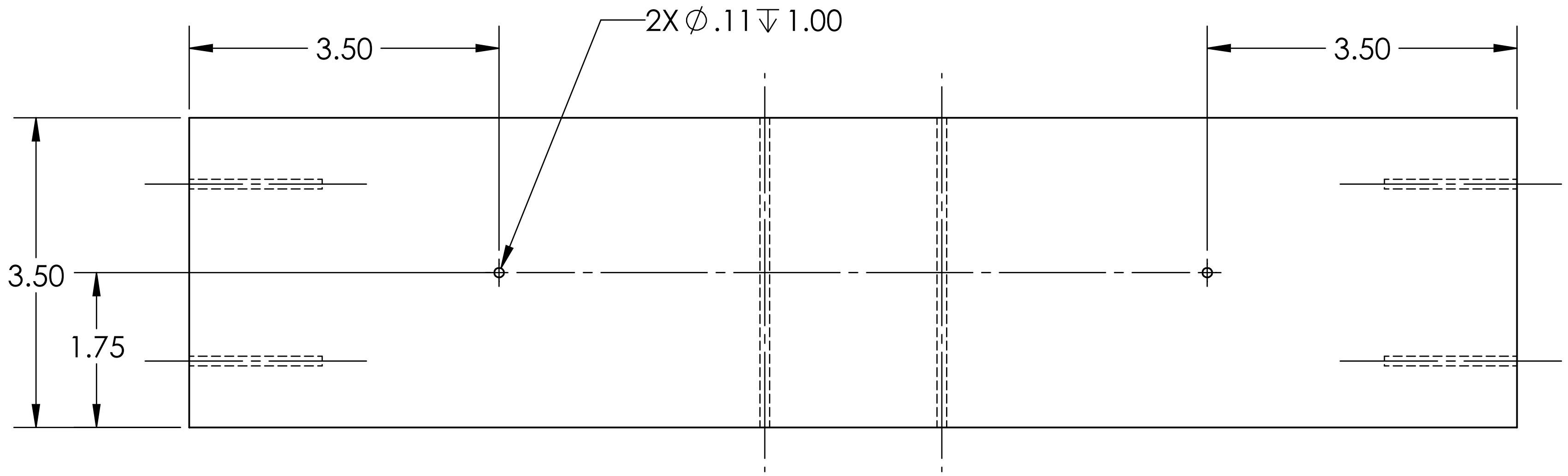
1. ALL DIMENSIONS IN INCHES
2. TOLERANCES:
   X = ±.1
   X.X = ±.05
   X.XX = ±.01
   ANGLES = ±2°

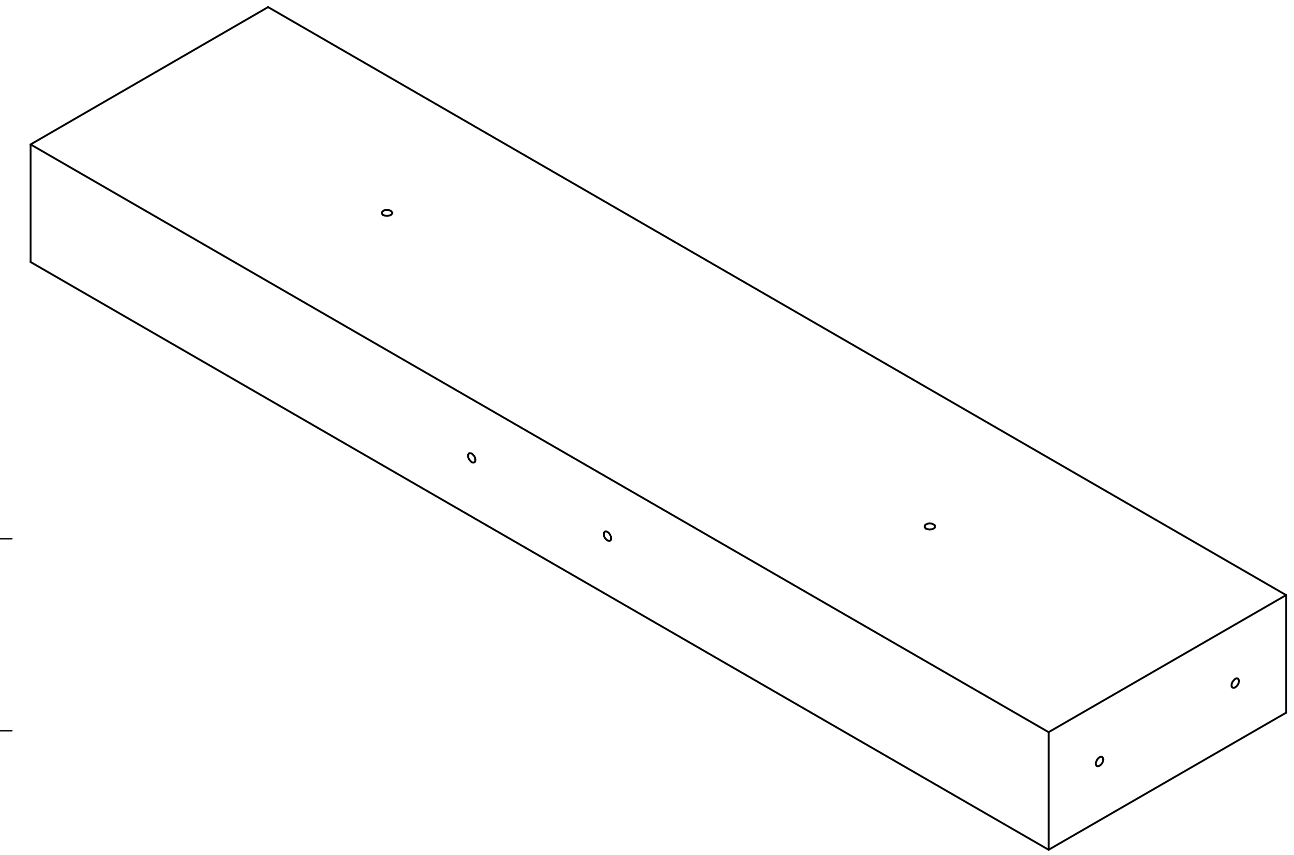
ALL HOLES ARE PILOT HOLES FOR #8 WOOD SCREWS

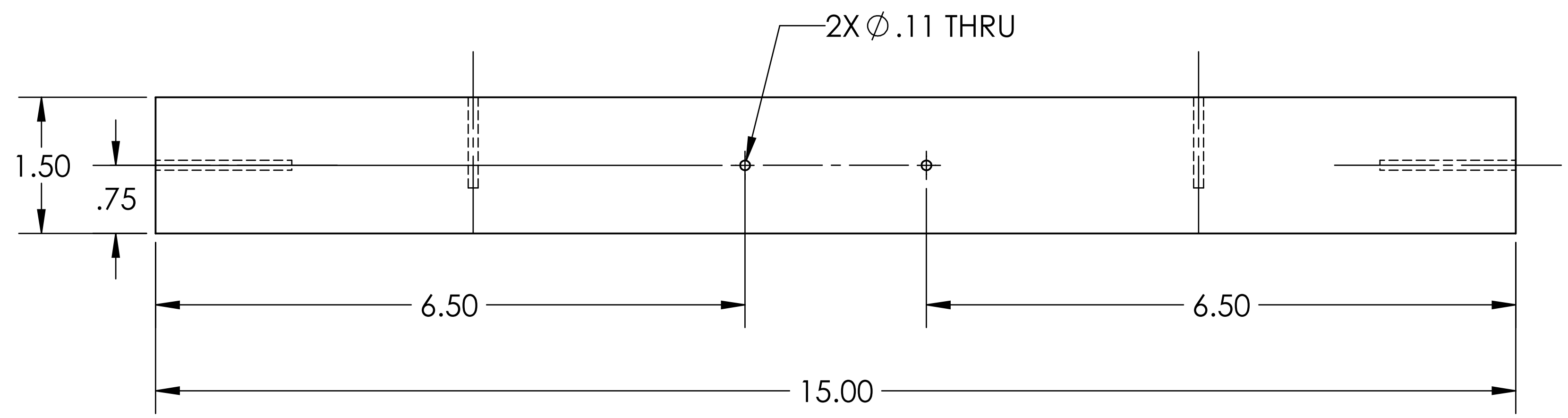
Material	Cal Poly Mechanical Engineering	Senior Project	Part #11111	Title: Footrest Side Beam		Drawn by: Andrew Nott
2x4 Wood	ME 428/429/430	RSVP Spaceship	Revision: 1.0	Date: 01/28/20	Scale: 1:4	Checked by: Taylor Chavez

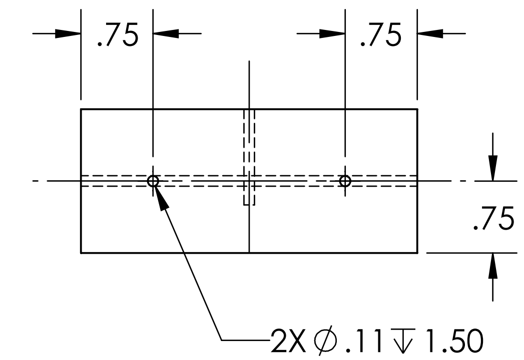
NOTES
UNLESS OTHERWISE SPECIFIED
1. ALL DIMENSIONS IN INCHES
2. TOLERANCES:
X = ±.1
X.X = ±.05
X.XX = ±.01
ANGLES = ±2°

ALL HOLES ARE PILOT HOLES FOR #8 WOOD SCREWS





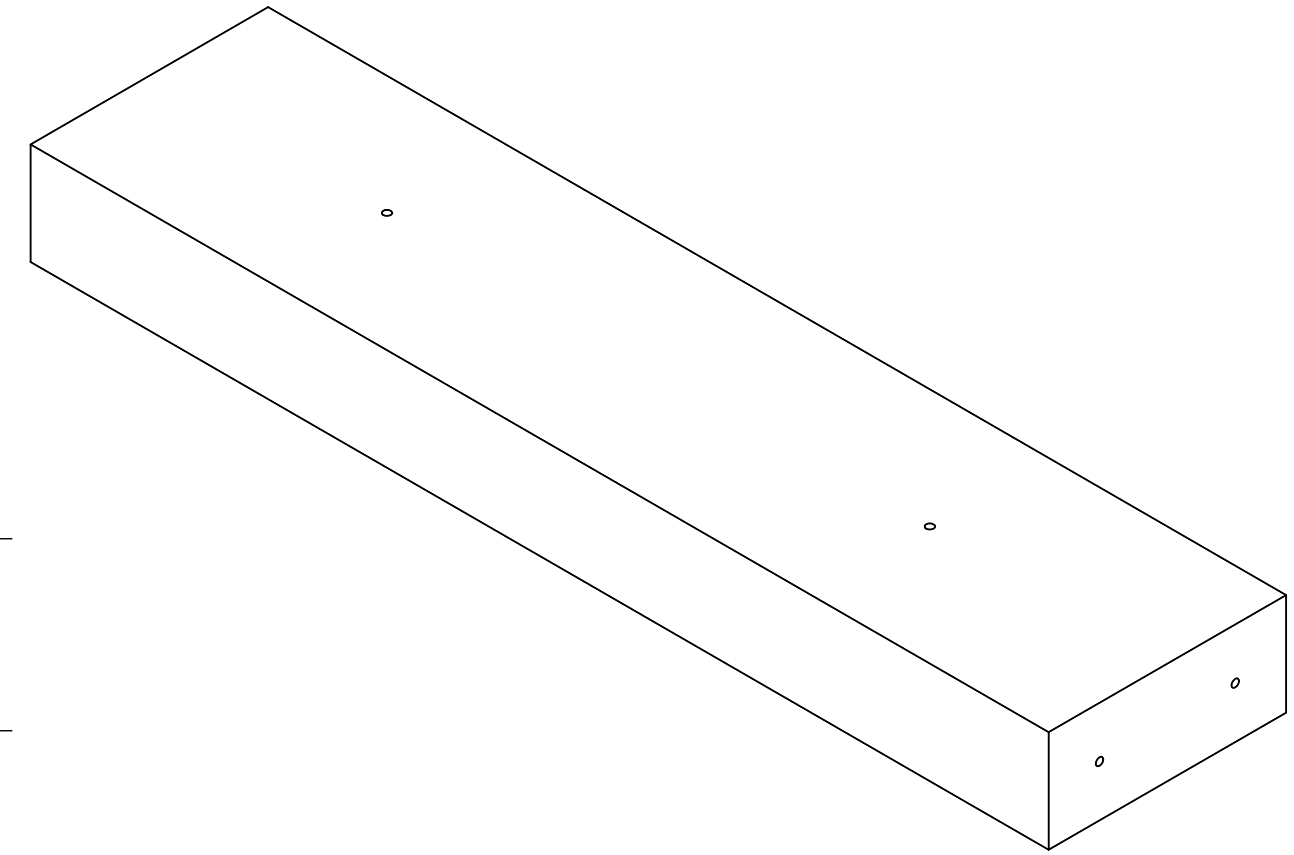


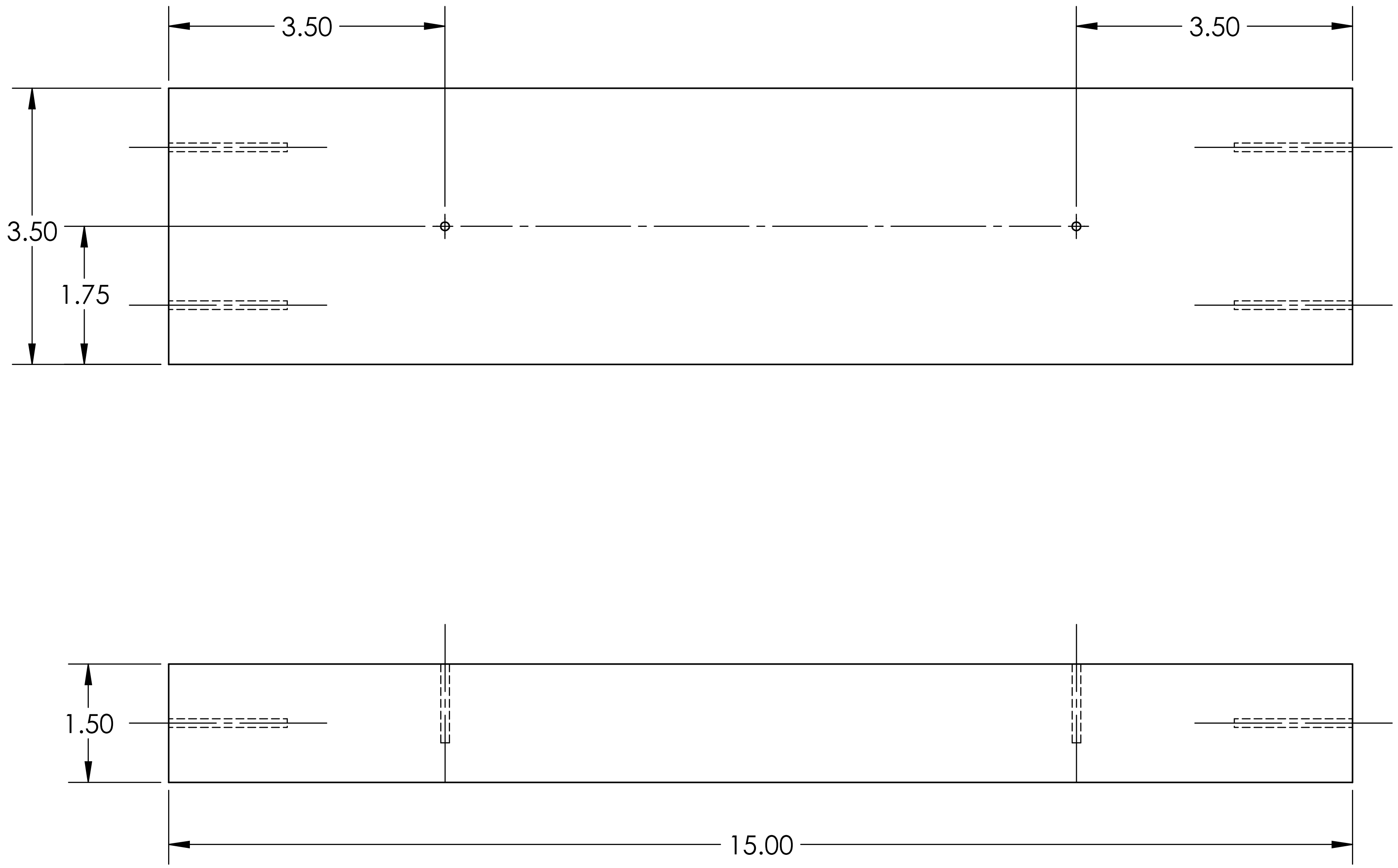


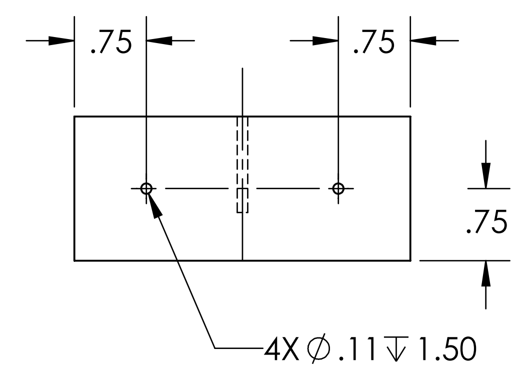
Material	Cal Poly Mechanical Engineering	Senior Project	Part #11112	Title: Seat Center Crossbeam		Drawn by: Andrew Nott
2x4 Wood	ME 428/429/430	RSVP Spaceship	Revision: 1.0	Date: 01/28/20	Scale: 1:2	Checked by: Taylor Chavez

NOTES
UNLESS OTHERWISE SPECIFIED
1. ALL DIMENSIONS IN INCHES
2. TOLERANCES:
X = ±.1
X.X = ±.05
X.XX = ±.01
ANGLES = ±2°

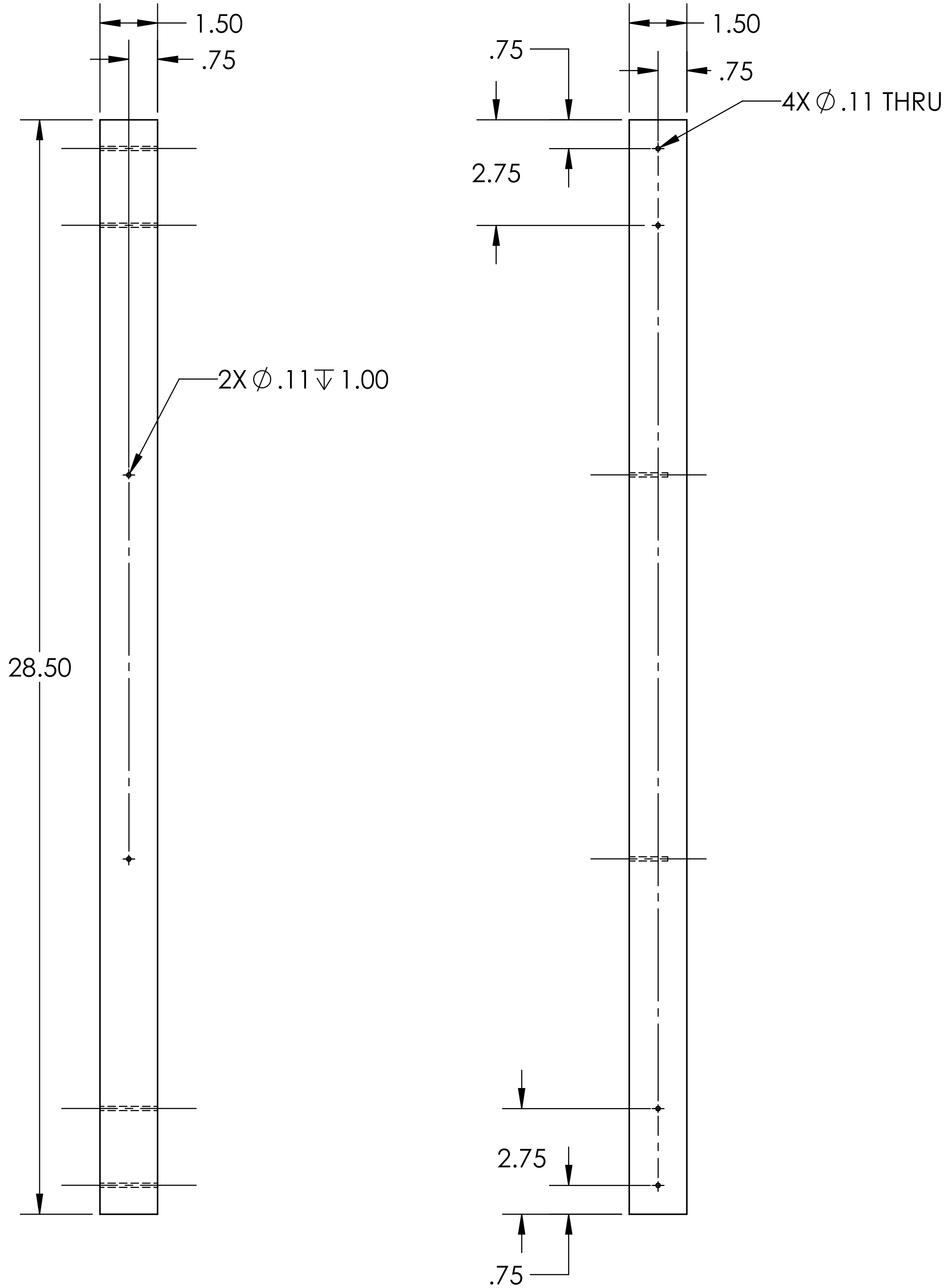
ALL HOLES ARE PILOT HOLES FOR #8 WOOD SCREWS

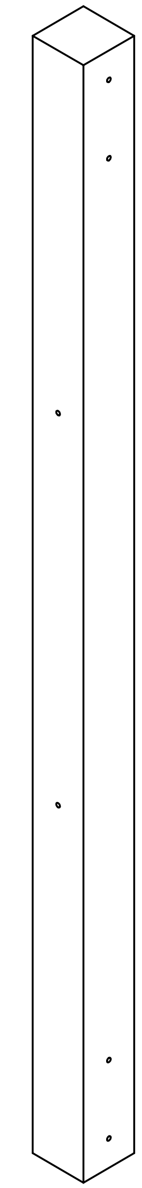






Material	Cal Poly Mechanical Engineering	Senior Project	Part #11113	Title: Seat Rear Crossbeam		Drawn by: Andrew Nott
2x4 Wood	ME 428/429/430	RSVP Spaceship	Revision: 1.0	Date: 01/28/20	Scale: 1:2	Checked by: Taylor Chavez





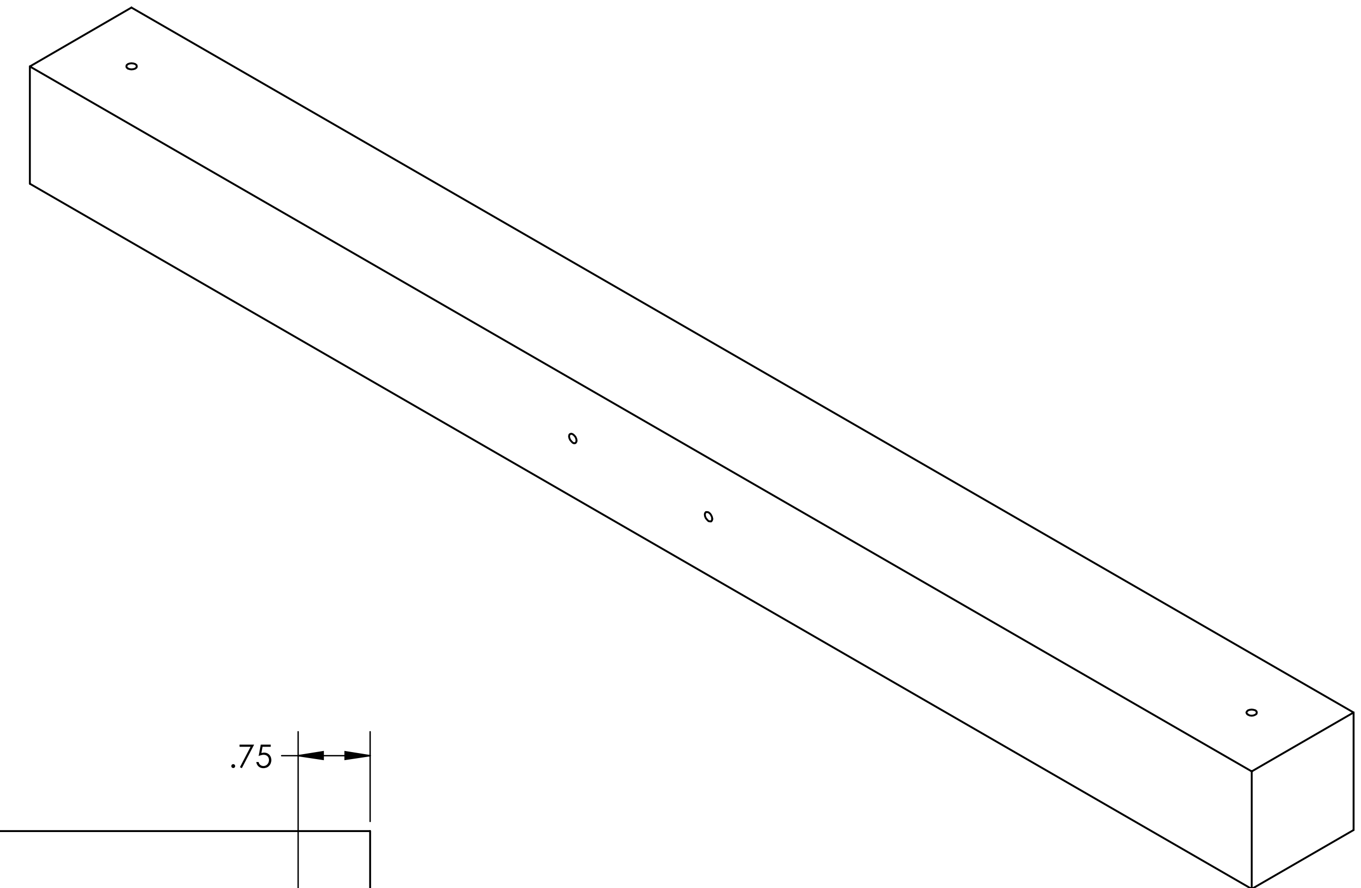
NOTES
UNLESS OTHERWISE SPECIFIED
1. ALL DIMENSIONS IN INCHES
2. TOLERANCES:
X = ±.1
X.X = ±.05
X.XX = ±.01
ANGLES = ±2°

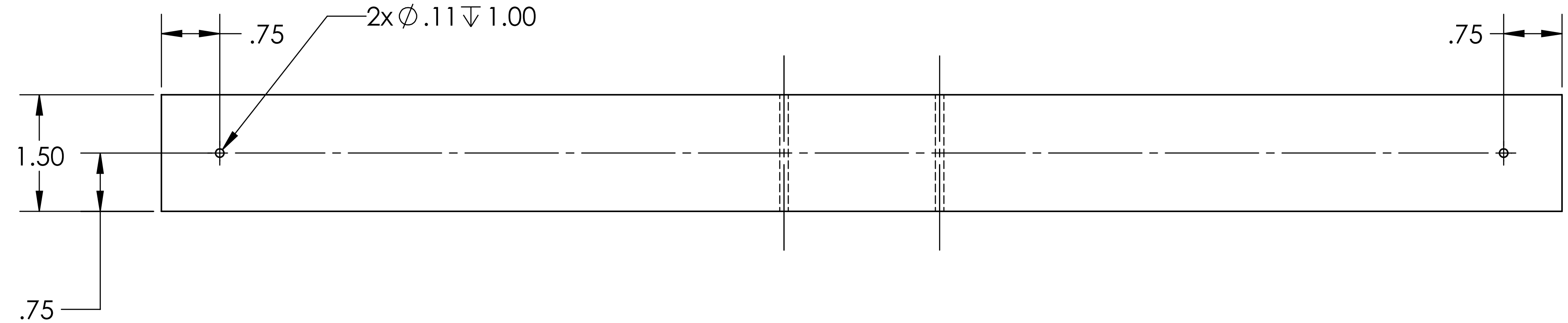
ALL HOLES ARE PILOT HOLES FOR #8 WOOD SCREWS

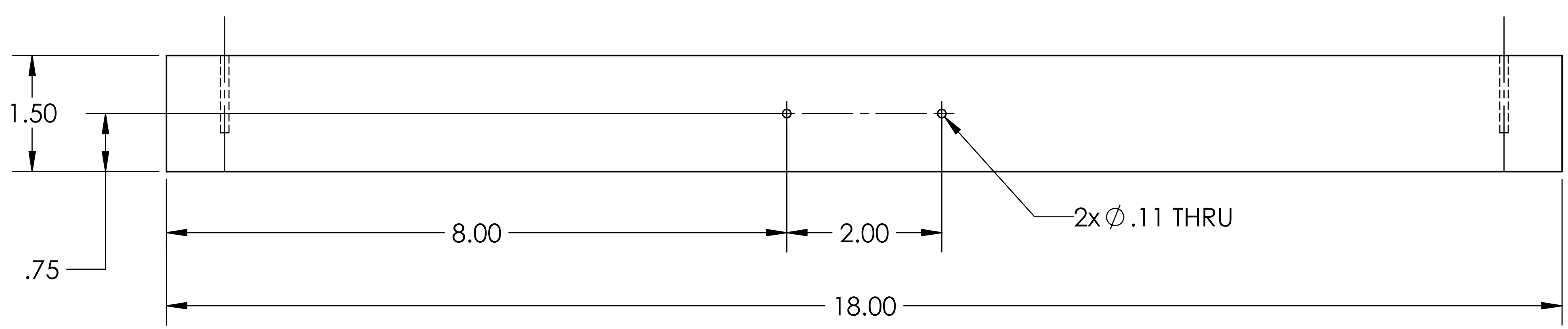
Material	Cal Poly Mechanical Engineering	Senior Project	Part #11114	Title: Seat Side Beams		Drawn by: Andrew Nott
2x2 Wood	ME 428/429/430	RSVP Spaceship	Revision: 1.0	Date: 01/28/20	Scale: 1:4	Checked by: Taylor Chavez

NOTES
UNLESS OTHERWISE SPECIFIED
1. ALL DIMENSIONS IN INCHES
2. TOLERANCES:
X = ±.1
X.X = ±.05
X.XX = ±.01
ANGLES = ±2°

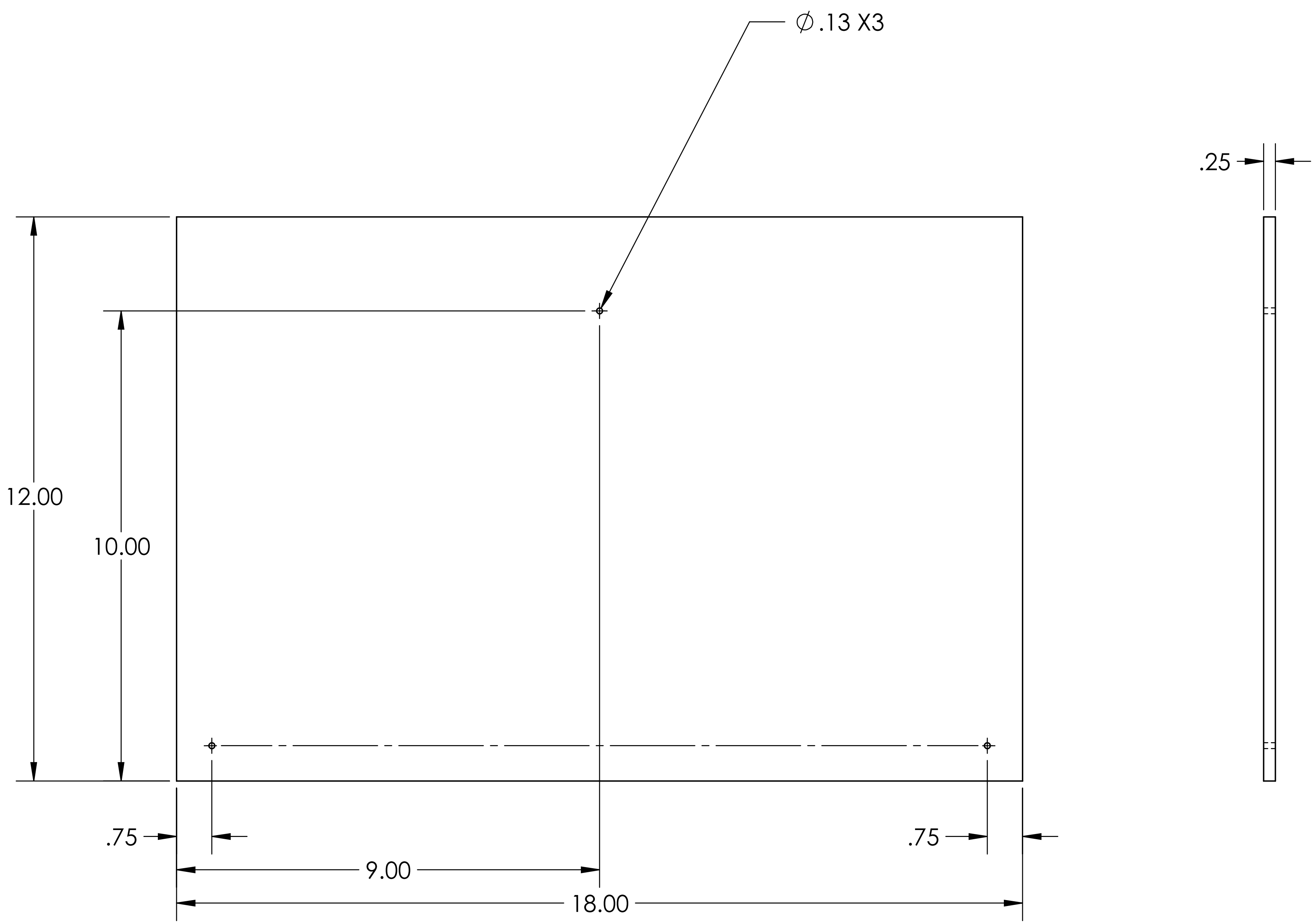
ALL HOLES ARE PILOT HOLES FOR #8 WOOD SCREWS

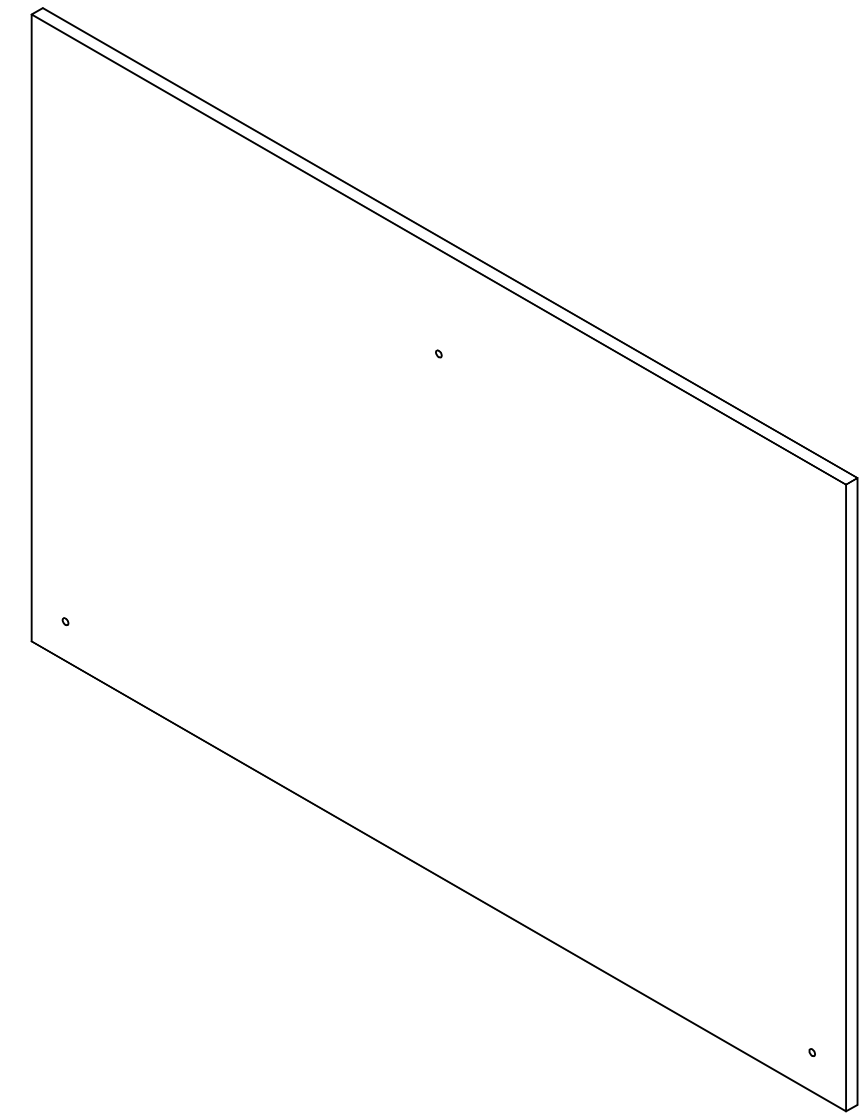






Material	Cal Poly Mechanical Engineering	Senior Project	Part #11115	Title: Footrest Beam		Drawn by: Andrew Nott
2x2 Wood	ME 428/429/430	RSVP Spaceship	Revision: 1.0	Date: 01/28/20	Scale: 1:2	Checked by: Taylor Chavez

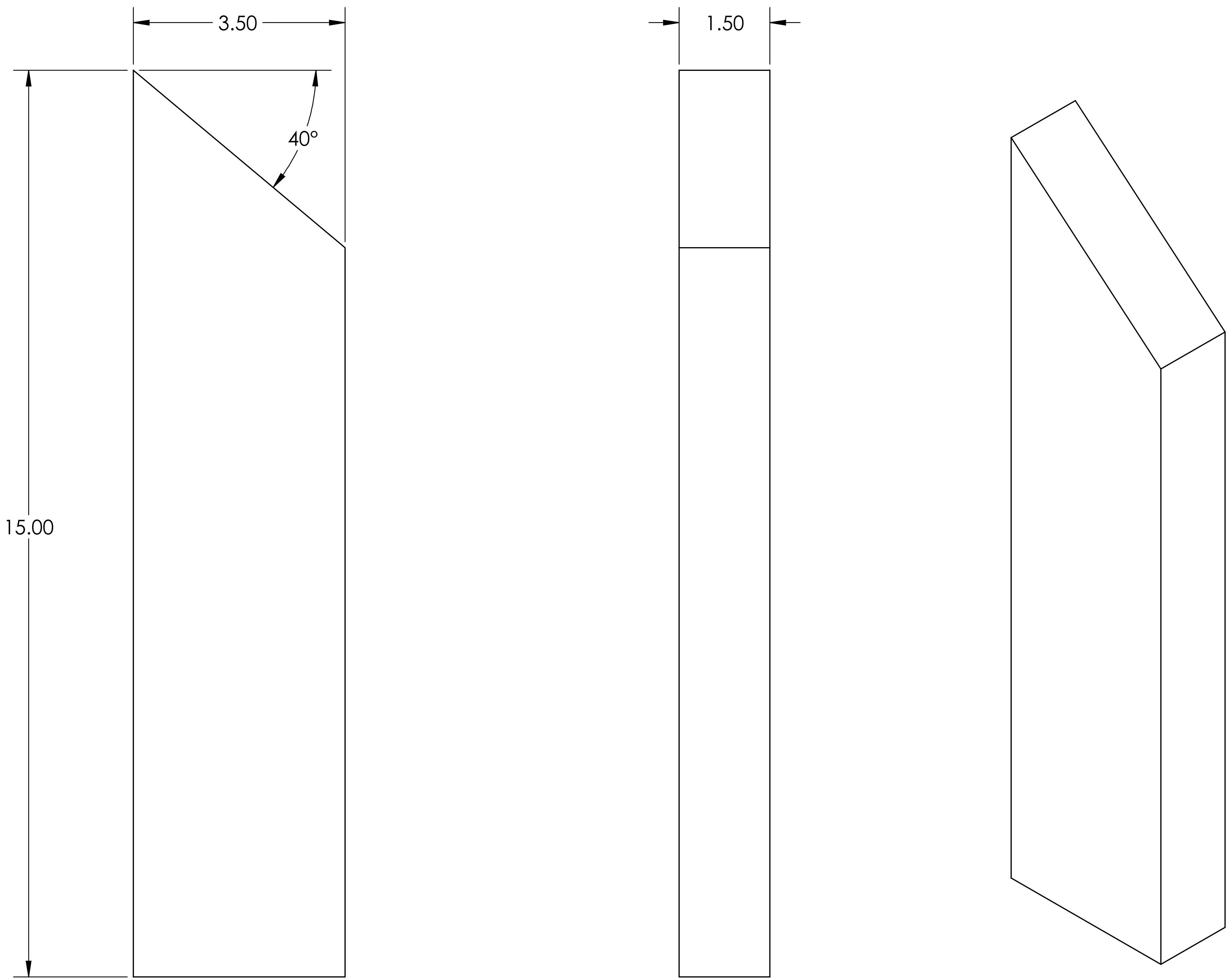




NOTES
UNLESS OTHERWISE SPECIFIED
1. ALL DIMENSIONS IN INCHES
2. TOLERANCES:
X = ±.1
X.X = ±.05
X.XX = ±.01
ANGLES = ±2°

ALL HOLES ARE PILOT HOLES FOR #8 WOOD SCREWS

Material	Cal Poly Mechanical Engineering	Senior Project	Part #11116	Title: Footrest Cover		Drawn by: Andrew Nott
1/4" MDF	ME 428/429/430	RSVP Spaceship	Revision: 1.0	Date: 01/28/20	Scale: 1:3	Checked by: Taylor Chavez



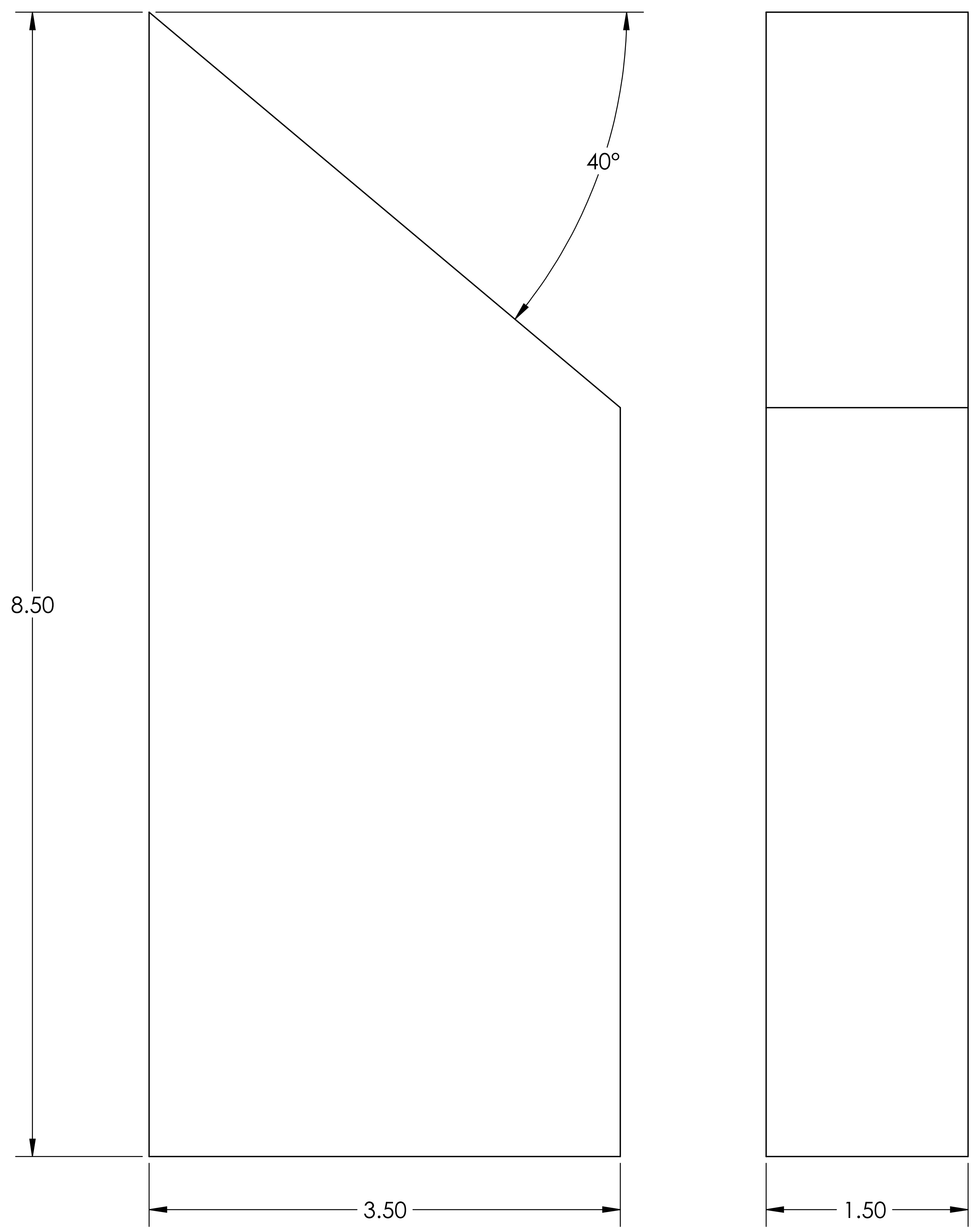
NOTES

UNLESS OTHERWISE SPECIFIED

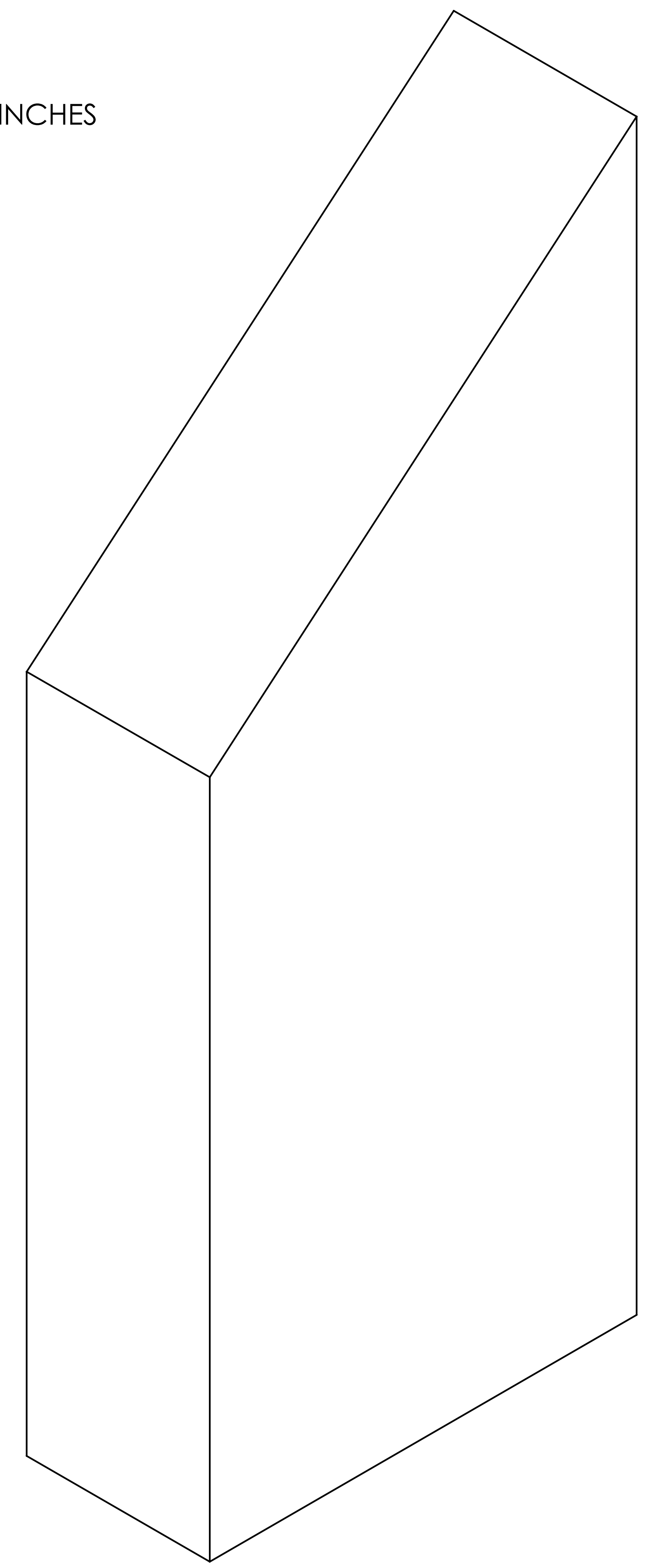
1. ALL DIMENSIONS IN INCHES
2. TOLERANCES:
   X = ±.1
   X.X = ±.05
   X.XX = ±.01
   ANGLES = ±2°

Material
2x4 Wood

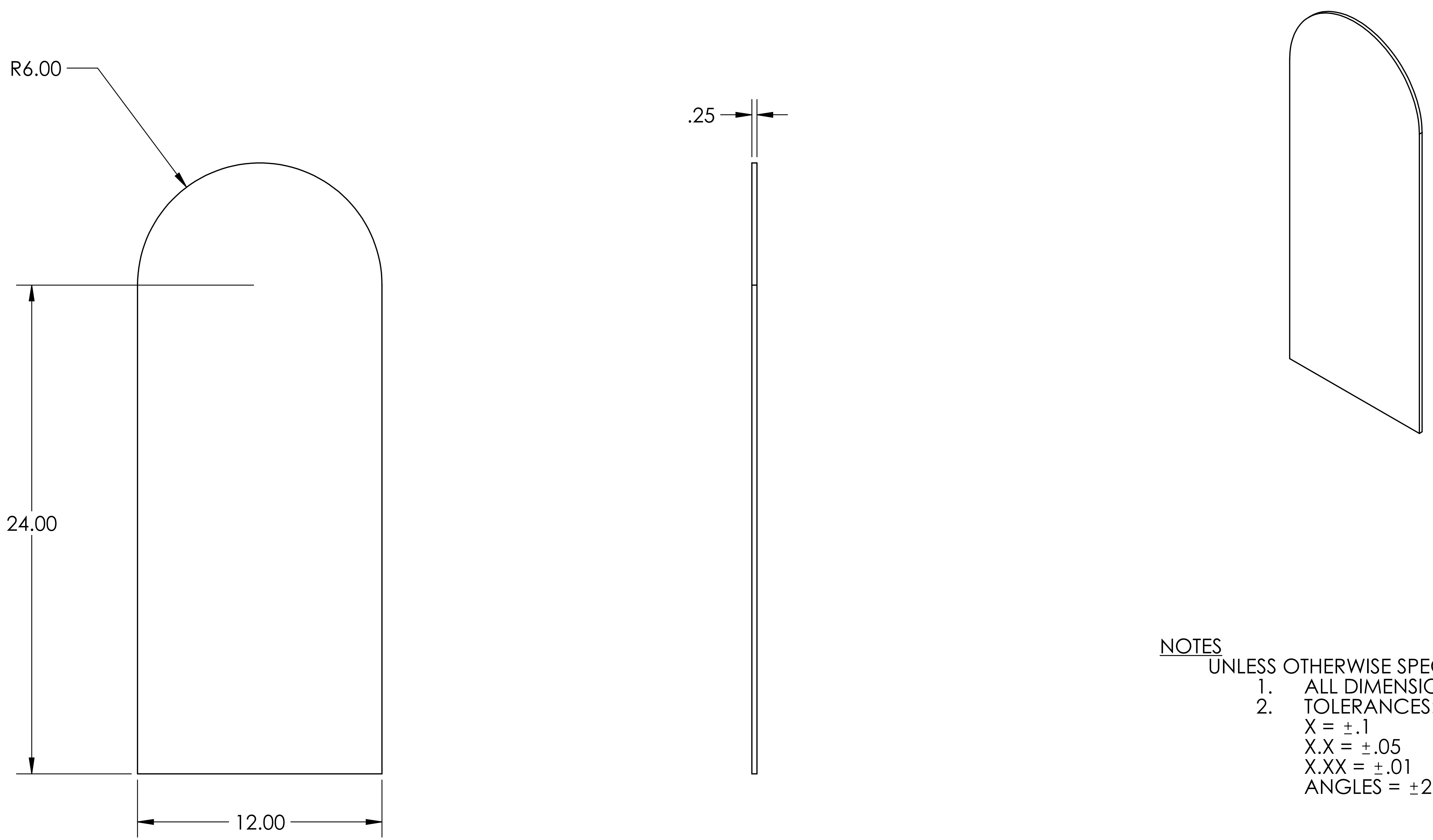
Cal Poly Mechanical Engineering	Senior Project	Part #11121	Title: Tall Back Rest Support		Drawn by: Andrew Nott
ME 428/429/430	RSVP Spaceship	Revision: 1.0	Date: 01/28/20	Scale: 1:2	Checked by: Taylor Chavez



NOTES
UNLESS OTHERWISE SPECIFIED
1. ALL DIMENSIONS IN INCHES
2. TOLERANCES:
X = ±.1
X.X = ±.05
X.XX = ±.01
ANGLES = ±2°

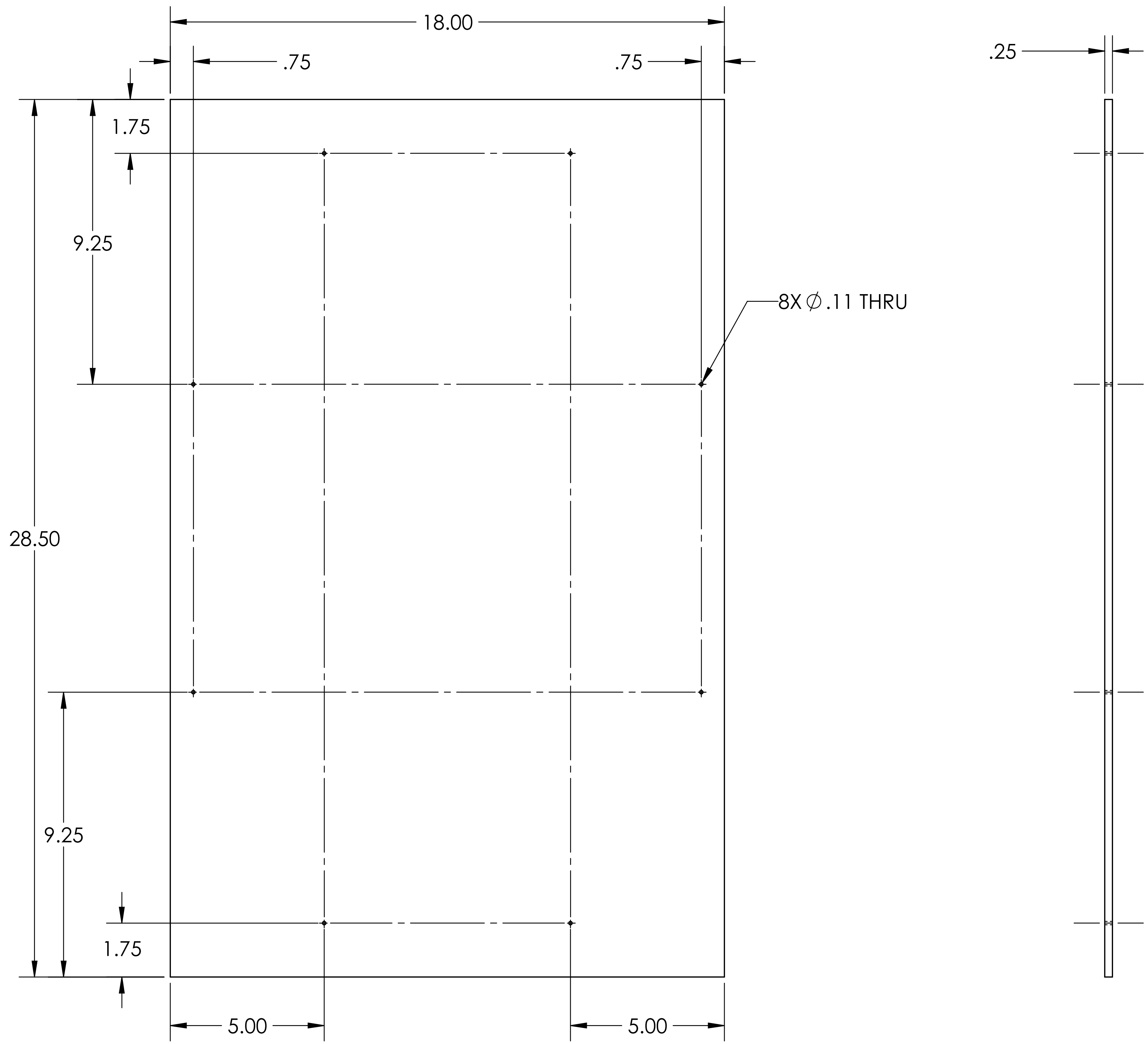


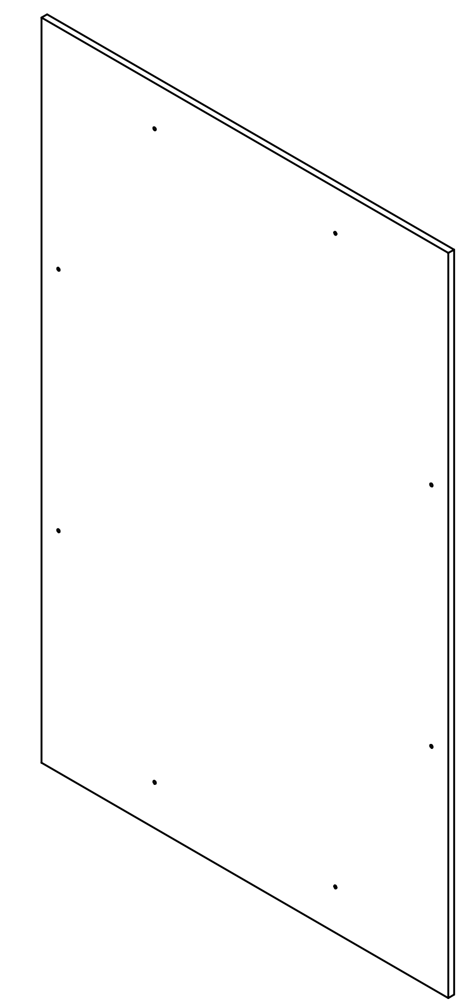
Material 2x4 Wood	Cal Poly Mechanical Engineering ME 428/429/430	Senior Project	Part #11122	Title: Short Back Rest Support		Drawn by: Andrew Nott
		RSVP Spaceship	Revision: 1.0	Date: 01/28/20	Scale: 1:1	Checked by: Taylor Chavez



NOTES
UNLESS OTHERWISE SPECIFIED
1. ALL DIMENSIONS IN INCHES
2. TOLERANCES:
X = ±.1
X.X = ±.05
X.XX = ±.01
ANGLES = ±2°

Material	Cal Poly Mechanical Engineering	Senior Project	Part #11123	Title: Back Rest		Drawn by: Andrew Nott
1/4" MDF	ME 428/429/430	RSVP Spaceship	Revision: 1.0	Date: 01/28/20	Scale: 1:6	Checked by: Taylor Chavez

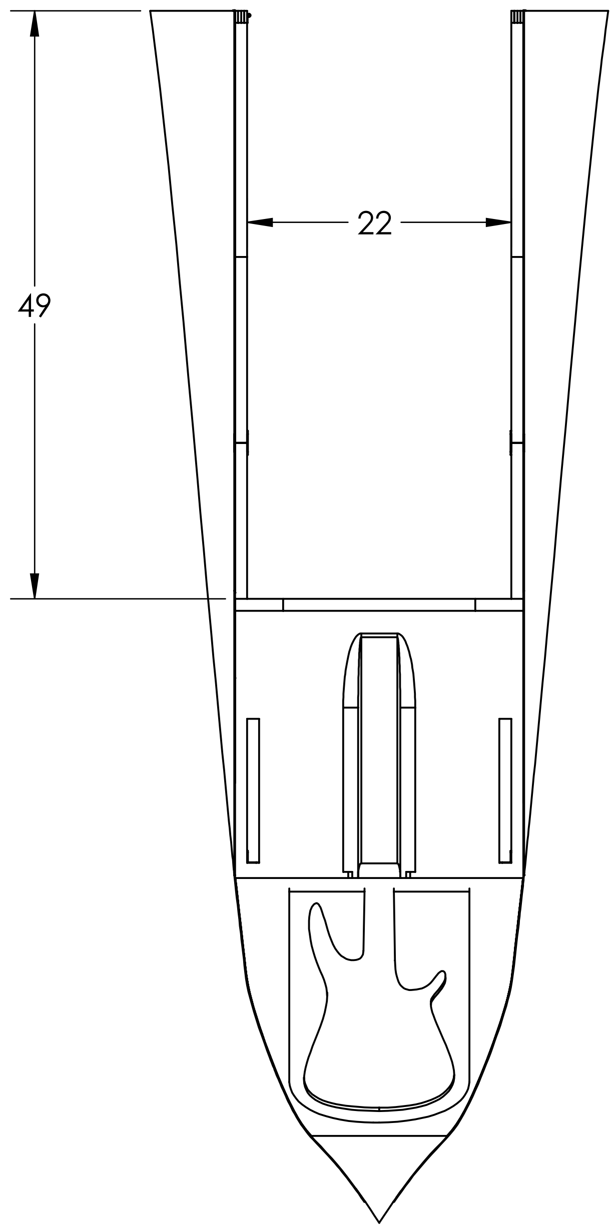




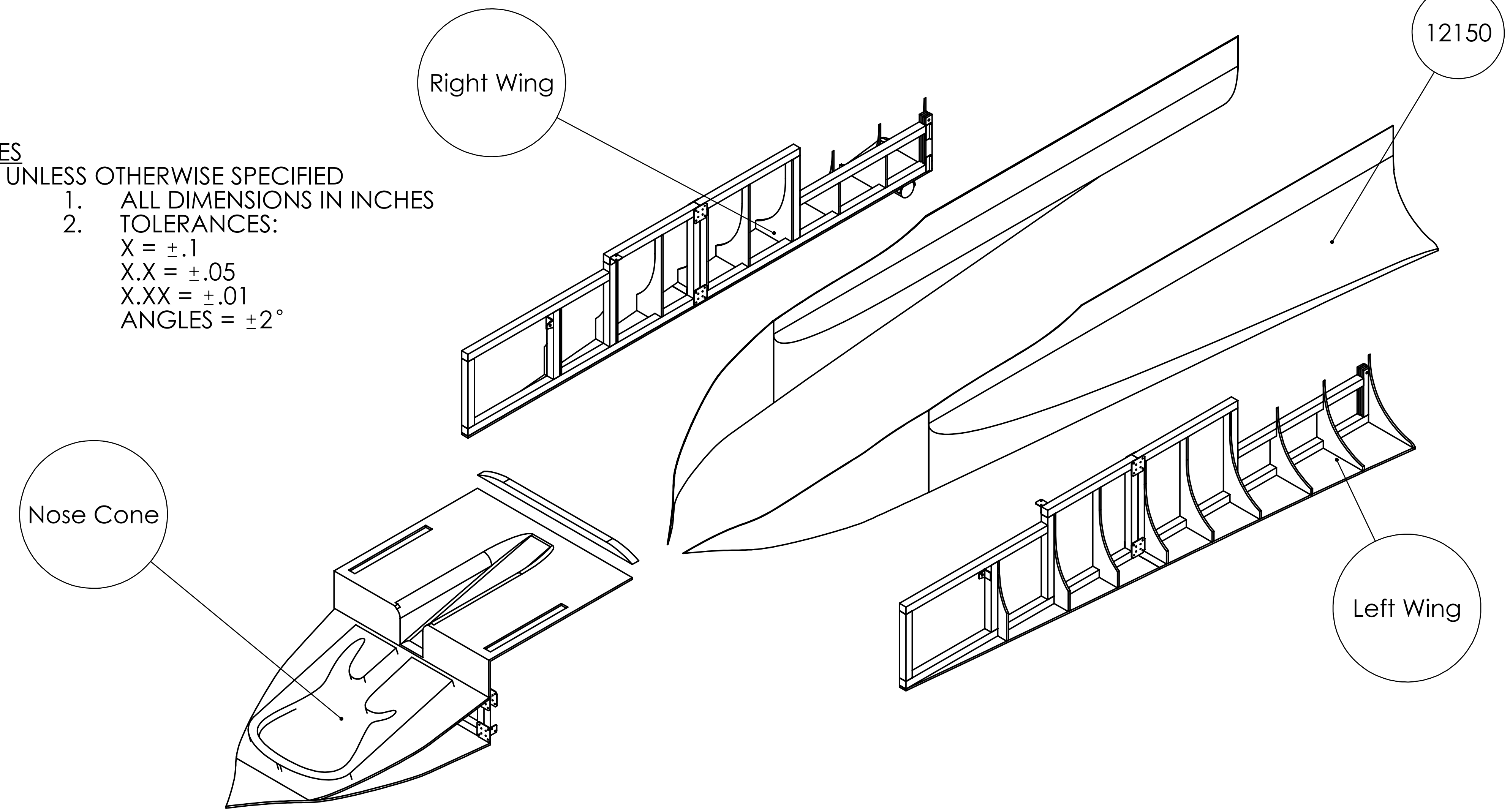
NOTES
UNLESS OTHERWISE SPECIFIED
1. ALL DIMENSIONS IN INCHES
2. TOLERANCES:
X = ±.1
X.X = ±.05
X.XX = ±.01
ANGLES = ±2°

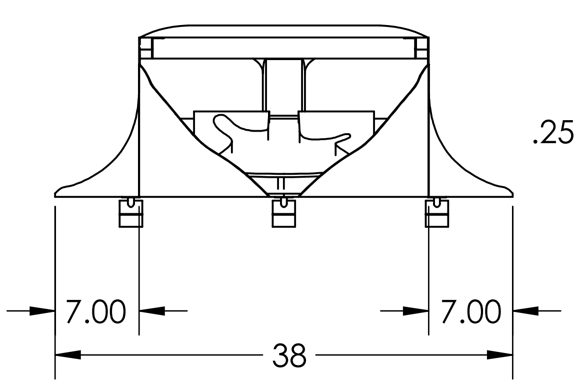
ALL HOLES ARE PILOT HOLES FOR #8 WOOD SCREWS

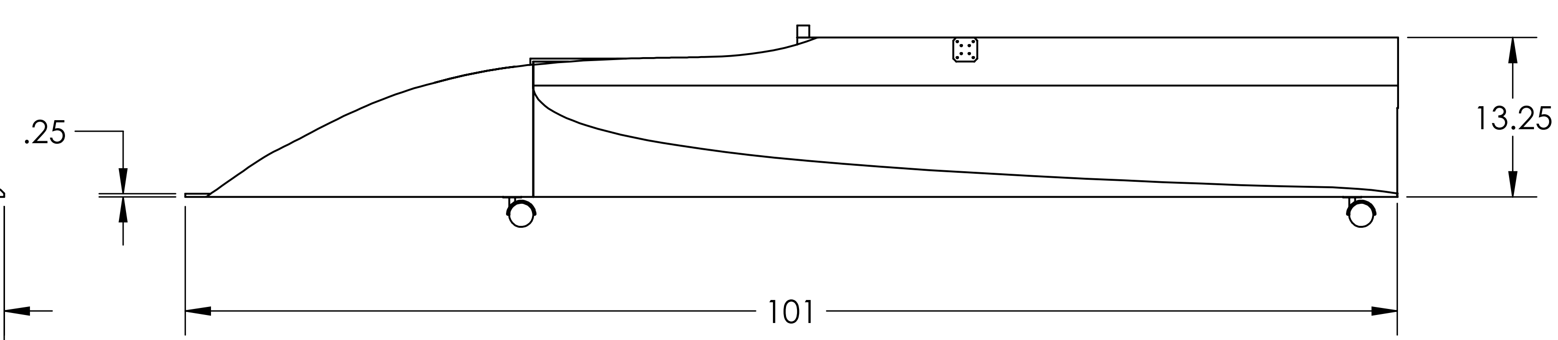
Material	Cal Poly Mechanical Engineering	Senior Project	Part #11141	Title: Seat Bottom Cover		Drawn by: Andrew Nott
1/4" MDF	ME 428/429/430	RSVP Spaceship	Revision: 1.0	Date: 01/28/20	Scale: 1:4	Checked by: Taylor Chavez



NOTES
UNLESS OTHERWISE SPECIFIED
1. ALL DIMENSIONS IN INCHES
2. TOLERANCES:
X = ±.1
X.X = ±.05
X.XX = ±.01
ANGLES = ±2°

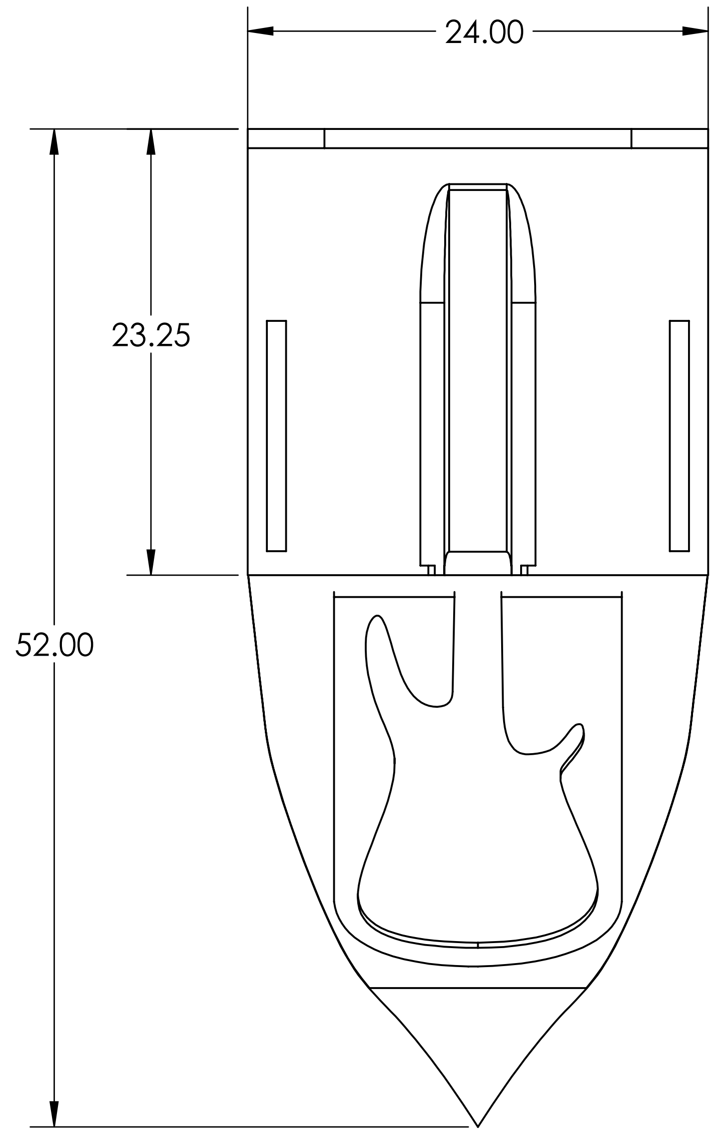


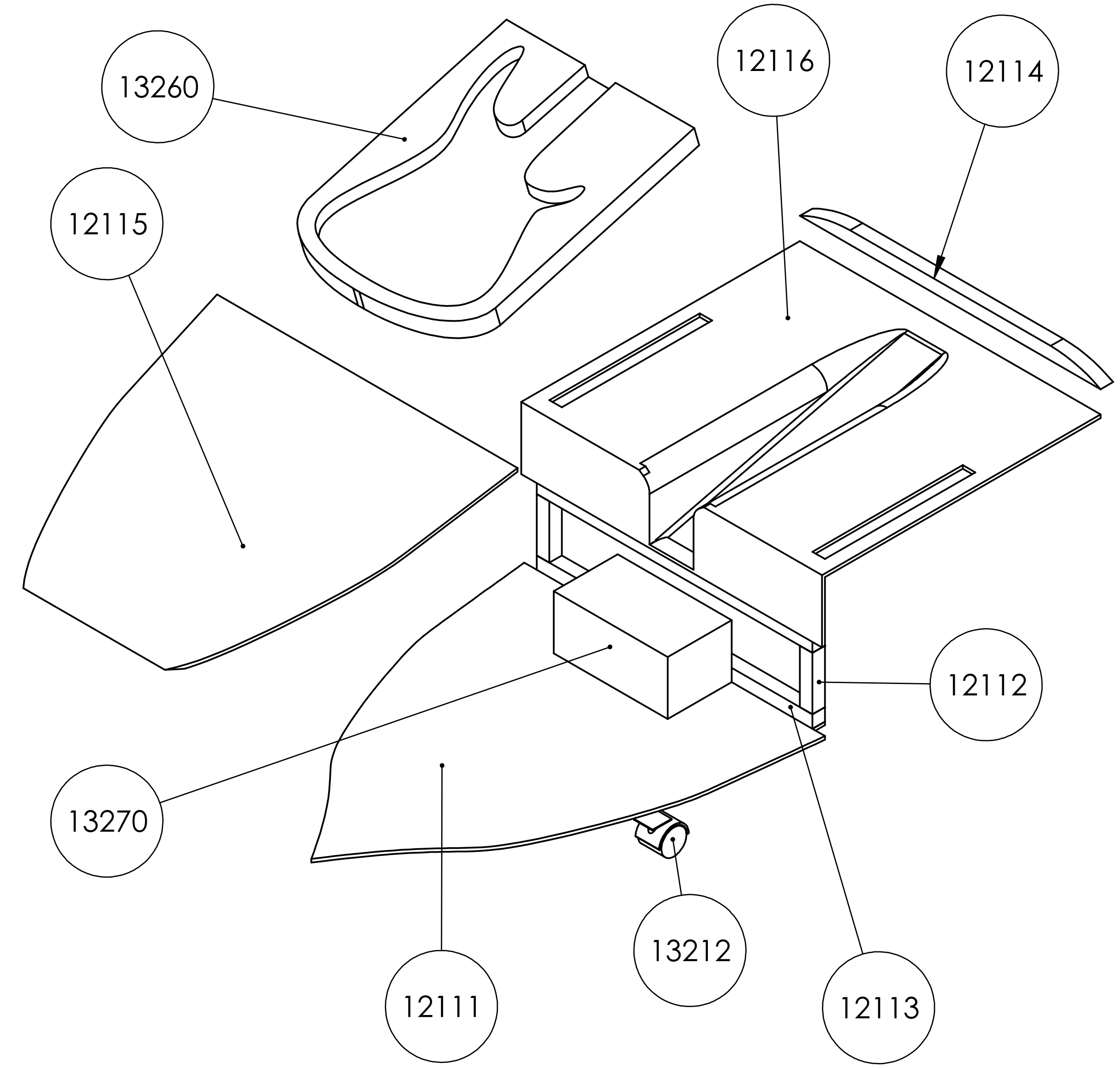




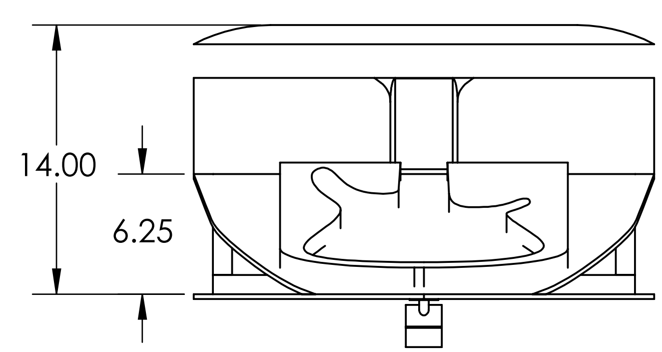
PART #	ASSEMBLY	
N/A	Nose Cone	1
N/A	Left Wing	1
N/A	Right Wing	1
12150	Fuselage Shell	1

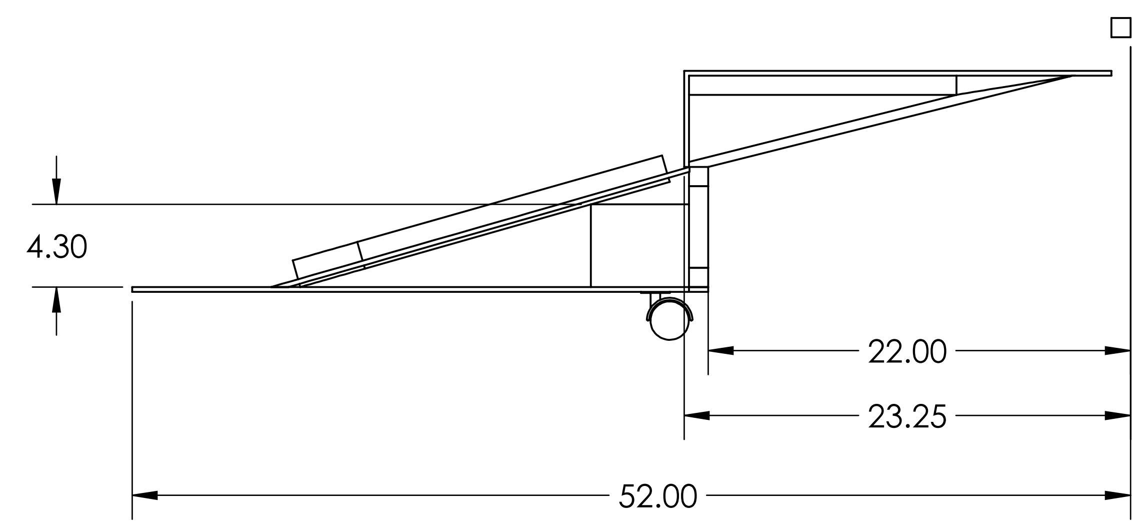
Cal Poly Mechanical Engineering	Senior Project	Part #12100	Title: Fuselage		Drawn by: Andrew Nott
ME 428/429/430	RSVP Spaceship	Revision: 1.0	Date: 01/28/20	Scale: 1:16	Checked by: Taylor Chavez





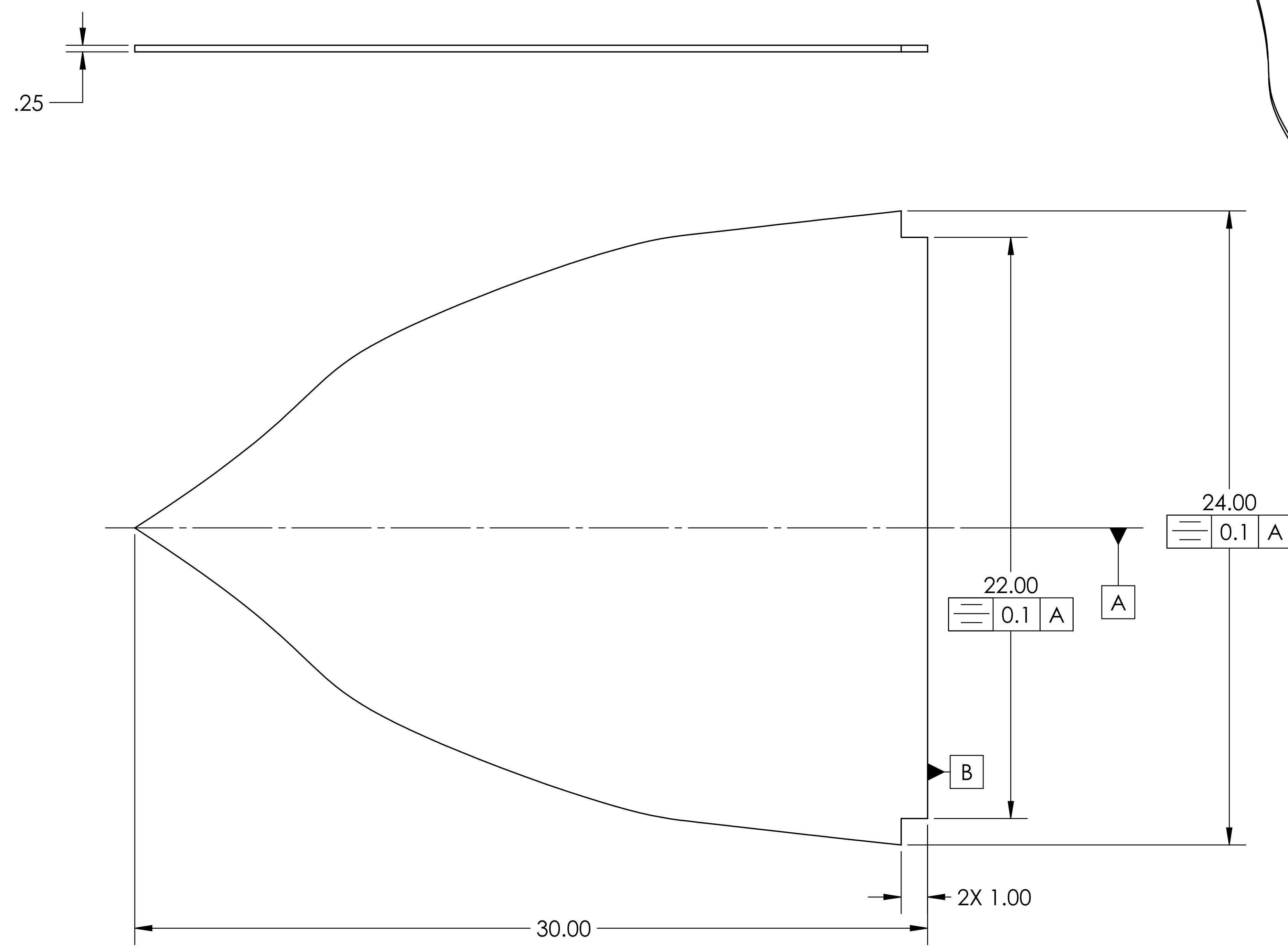
NOTES
UNLESS OTHERWISE SPECIFIED
1. ALL DIMENSIONS IN INCHES
2. TOLERANCES:
X = ±.1
X.X = ±.05
X.XX = ±.01
ANGLES = ±2°

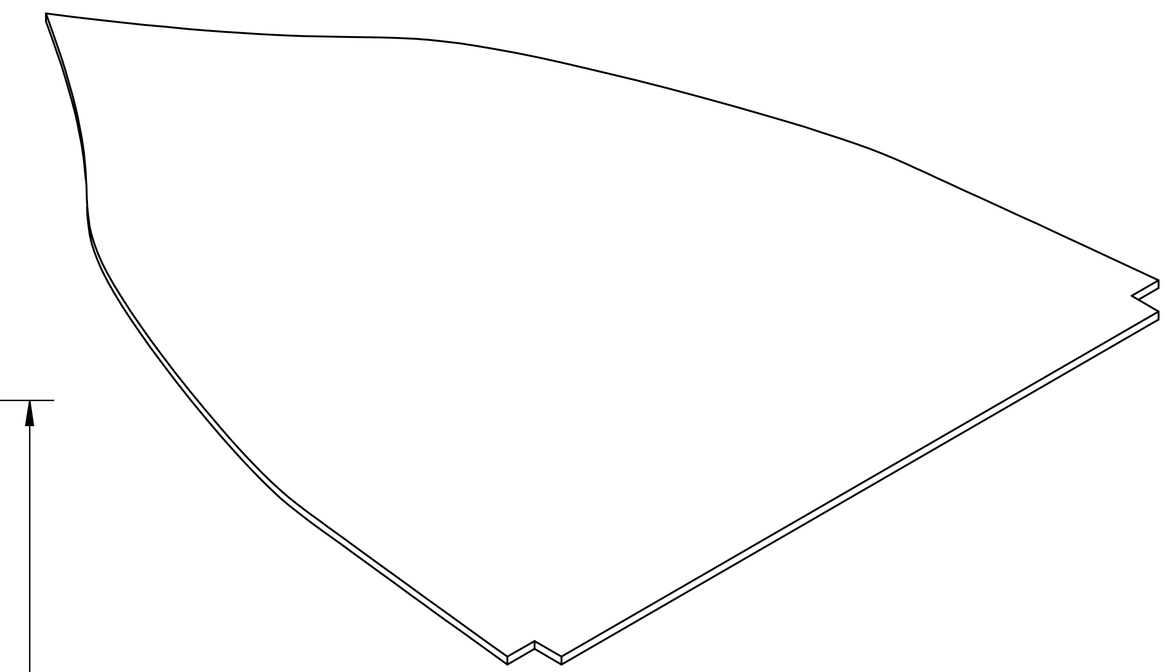




PART #	PART	MATERIAL	QTY.
12111	Nose Base	1/4" MDF	1
12112	1x1 4.25in	1x1 Square Dowel Rod	2
12113	1x1 22in	1x1 Square Dowel Rod	2
12114	Fuselage Crossbeam	1x1 Square Dowel Rod	1
12115	Slanted Hood Interior	1/4" MDF	1
12116	Hood Interior	1/4" MDF	1
13260	Guitar Case	-	1
13270	Fog Machine	-	1
13212	Castor	-	1

Cal Poly Mechanical Engineering ME 428/429/430	Senior Project	Part #N/A	Title: Nose Cone		Drawn by: Andrew Nott
	RSVP Spaceship	Revision: 1.0	Date: 01/29/20	Scale: 1:10	Checked by: Taylor Chavez





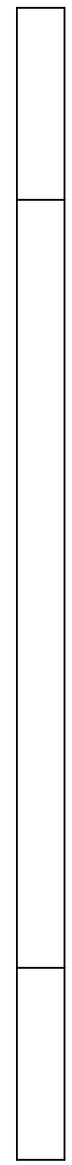
NOTES

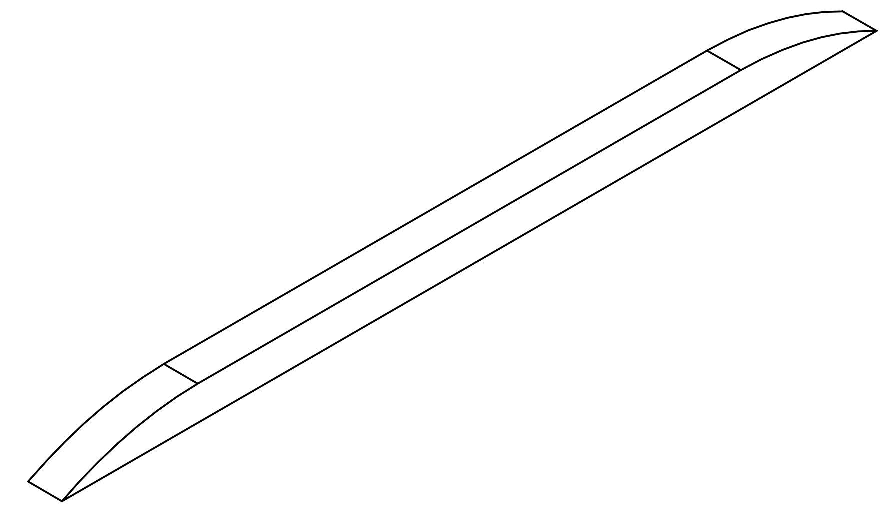
UNLESS OTHERWISE SPECIFIED

1. ALL DIMENSIONS IN INCHES
2. TOLERANCES:
   - X = ±.1
   - X.X = ±.05
   - X.XX = ±.01
   - ANGLES = ±2°

MANUFACTURE CURVE BY PRINTING FULL SCALE TEMPLATE AND CUTTING ALONG THE LINES

Material	Cal Poly Mechanical Engineering	Senior Project	Part #12111	Title: Nose Base		Drawn by: Andrew Nott
1/4" MDF	ME 428/429/430	RSVP Spaceship	Revision: 1.0	Date: 01/29/20	Scale: 1:4	Checked by: Taylor Chavez



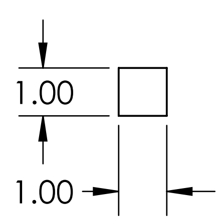


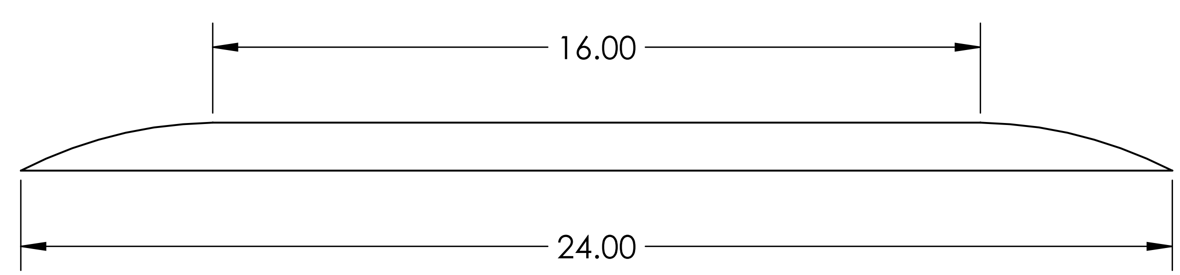
NOTES

UNLESS OTHERWISE SPECIFIED

1. ALL DIMENSIONS IN INCHES
2. TOLERANCES:
   X = ±.1
   X.X = ±.05
   X.XX = ±.01
   ANGLES = ±2°

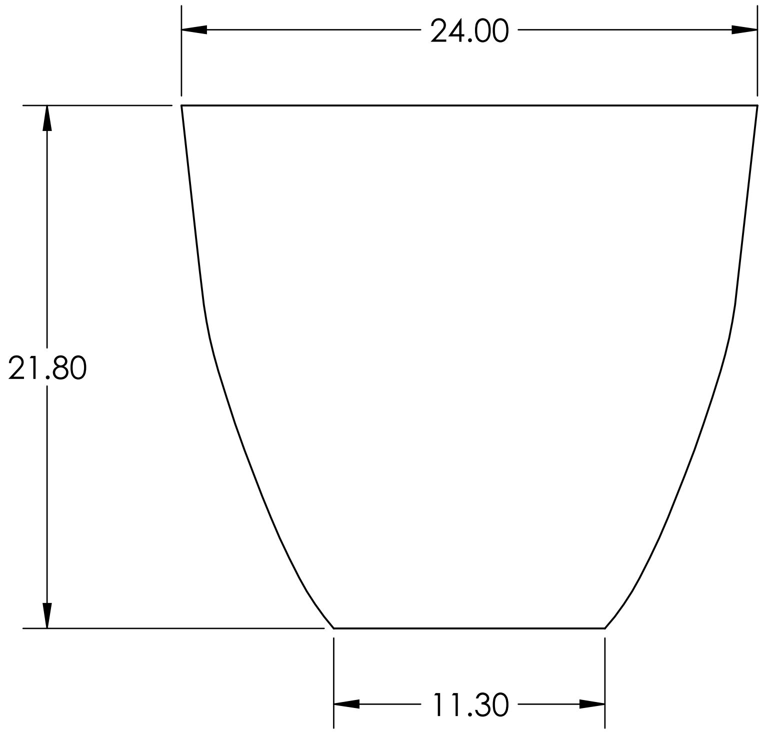
Exact curve is unimportant, just sand down

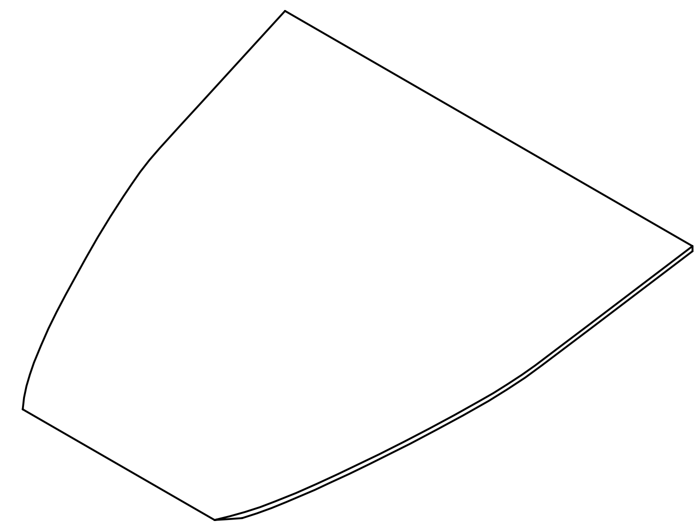




Material
1x1" SquareDowel

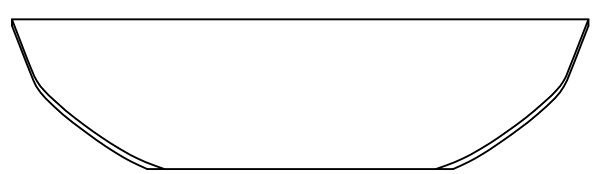
Cal Poly Mechanical Engineering	Senior Project	Part #12114	Title: Fuselage Crossbeam		Drawn by: Andrew Nott
ME 428/429/430	RSVP Spaceship	Revision: 1.0	Date: 01/28/20	Scale: 1:4	Checked by: Taylor Chavez

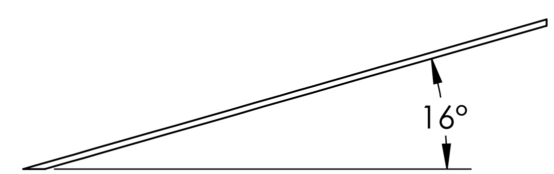




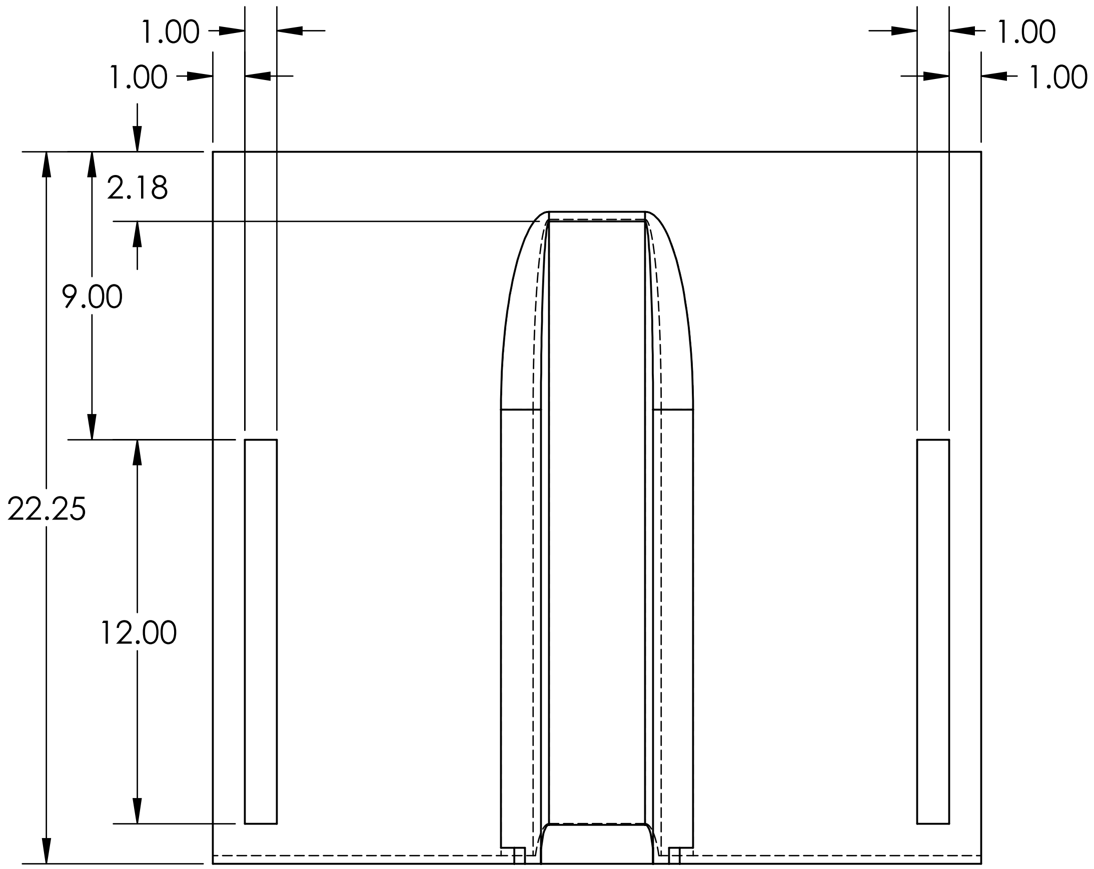
NOTES
UNLESS OTHERWISE SPECIFIED
1. ALL DIMENSIONS IN INCHES
2. TOLERANCES:
X = ±.1
X.X = ±.05
X.XX = ±.01
ANGLES = ±2°

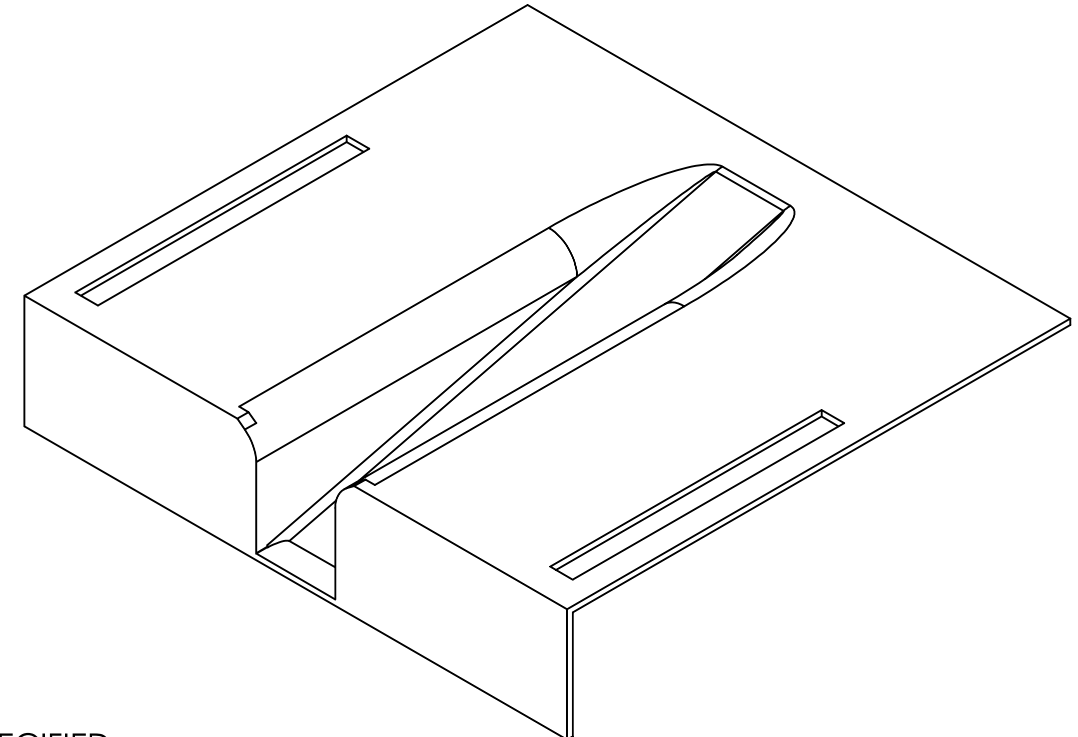
PRINT EXACT CURVE AND CUT TO TEMPLATE



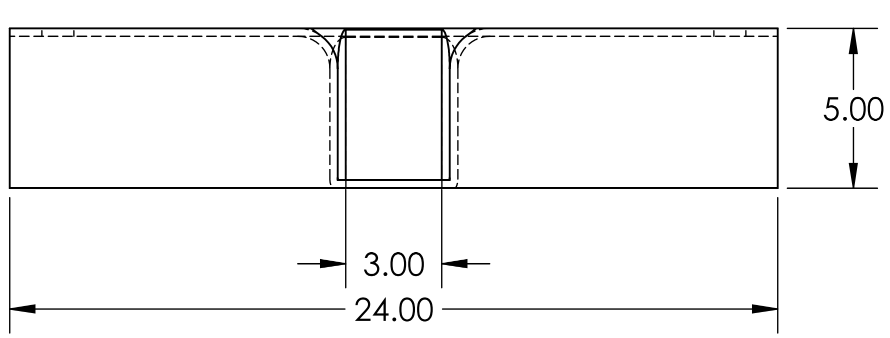


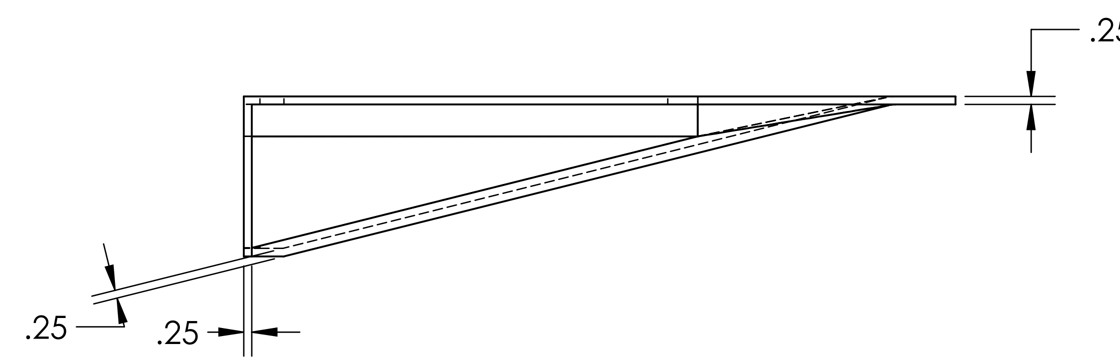
Material 1/4" MDF	Cal Poly Mechanical Engineering ME 428/429/430	Senior Project	Part #12115	Title: Slanted Hood Interior		Drawn by: Andrew Nott
		RSVP Spaceship	Revision: 1.0	Date: 01/28/20	Scale: 1:4	Checked by: Taylor Chavez





NOTES
UNLESS OTHERWISE SPECIFIED
1. ALL DIMENSIONS IN INCHES
2. TOLERANCES:
X = ±.1
X.X = ±.05
X.XX = ±.01
ANGLES = ±2°

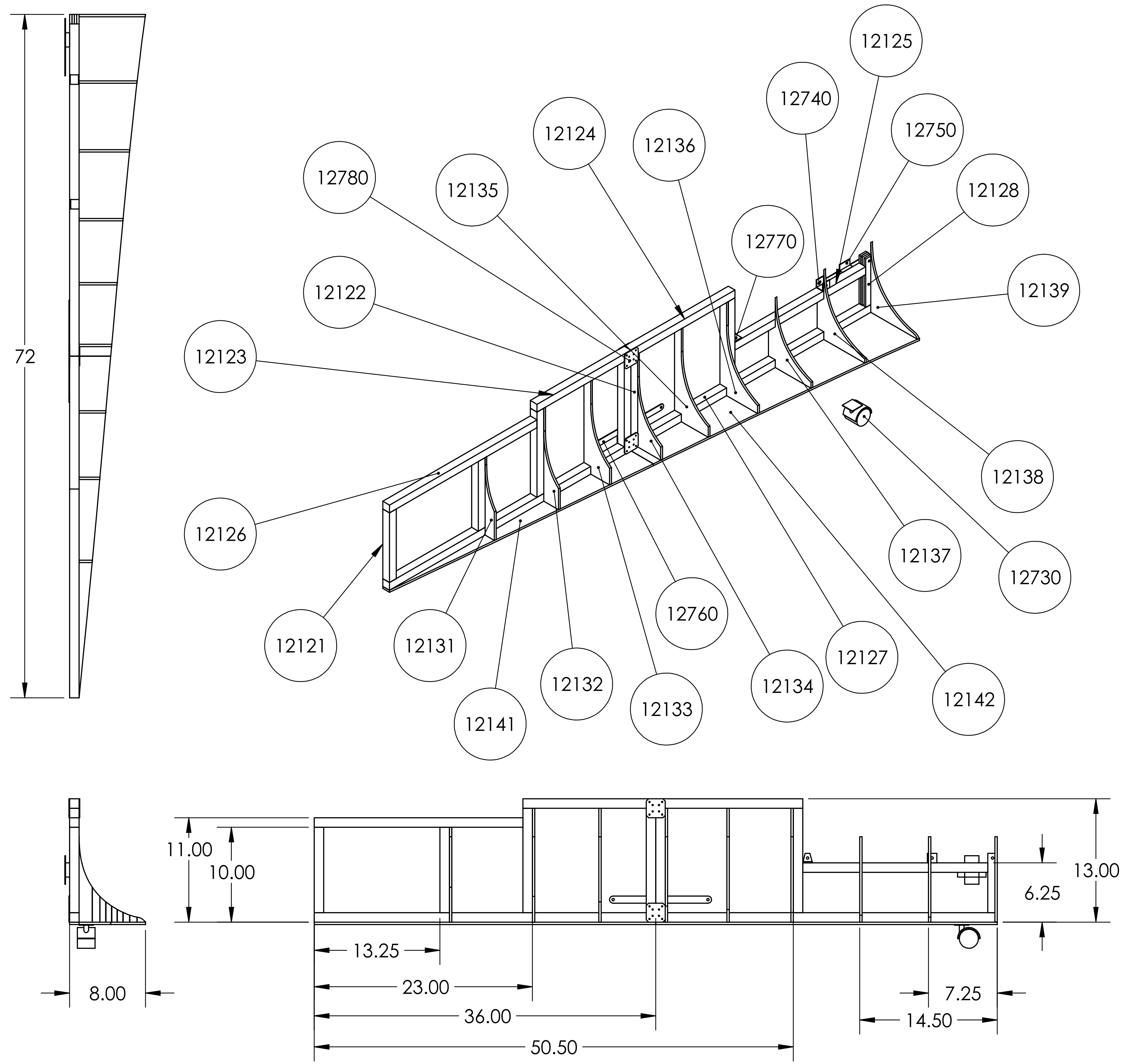




Material 1/4" MDF	Cal Poly Mechanical Engineering ME 428/429/430	Senior Project	Part #12116	Title: Hood Interior	Drawn by: Andrew Nott
		RSVP Spaceship	Revision: 1.0	Date: 01/28/20 — Scale: 1:6	Checked by: Taylor Chavez

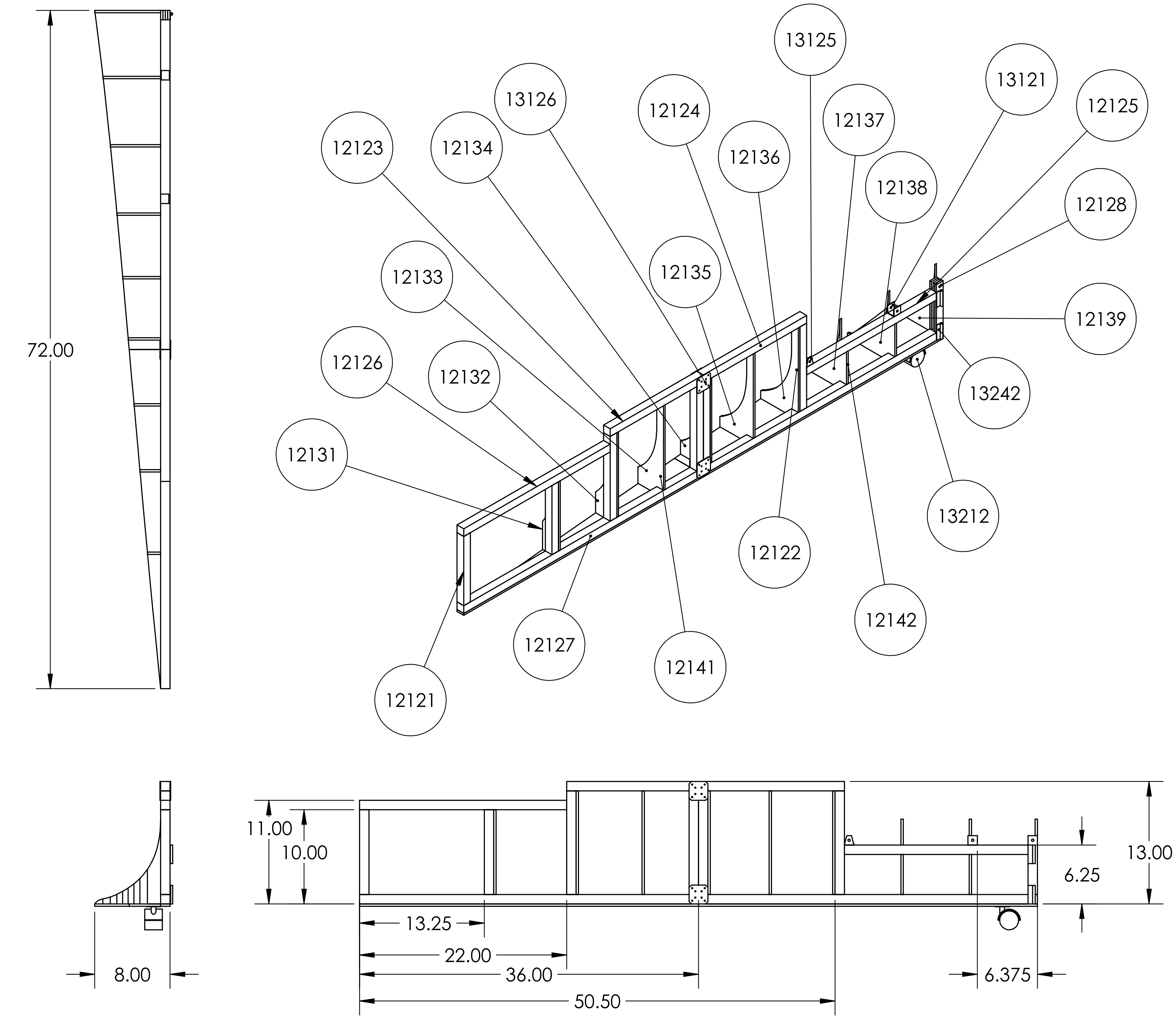
NOTES
UNLESS OTHERWISE SPECIFIED
1. ALL DIMENSIONS IN INCHES
2. TOLERANCES:
X = ±.1
X.X = ±.05
X.XX = ±.01
ANGLES = ±2°

PART #	PART	MATERIAL	QTY.
12121	1x1 9in	1x1 Square Dowel Rod	2
12122	1x1 11in	1x1 Square Dowel Rod	4
12123	1x1 14in	1x1 Square Dowel Rod	1
12124	1x1 15.5in	1x1" Square Dowel Rod	1
12125	1x1 19.5in	1x1 Square Dowel Rod	1
12126	1x1 22in	1x1 Square Dowel Rod	1
12127	1x1 36in	1x1 Square Dowel Rod	2
12128	Vertical Beam	1x1 Square Dowel Rod	3
12131	Wing Structure 1	1/4" MDF	2
12132	Wing Structure 2	1/4" MDF	1
12133	Wing Structure 3	1/4" MDF	1
12134	Wing Structure 4	1/4" MDF	1
12135	Wing Structure 5	1/4" MDF	1
12136	Wing Structure 6	1/4" MDF	1
12137	Wing Structure 7	1/4" MDF	1
12138	Wing Structure 8	1/4" MDF	1
12139	Wing Structure 9	1/4" MDF	1
12141	Wing Base (Front)	1/4" MDF	1
12142	Wing Base (Rear)	1/4" MDF	1
12730	Castor	-	1
12740	U Bracket	-	1
12750	Gate Latch	-	1
12760	Safety Lever	-	1
12770	Piston Bracket	-	1
12780	Flat Square Bracket	-	4



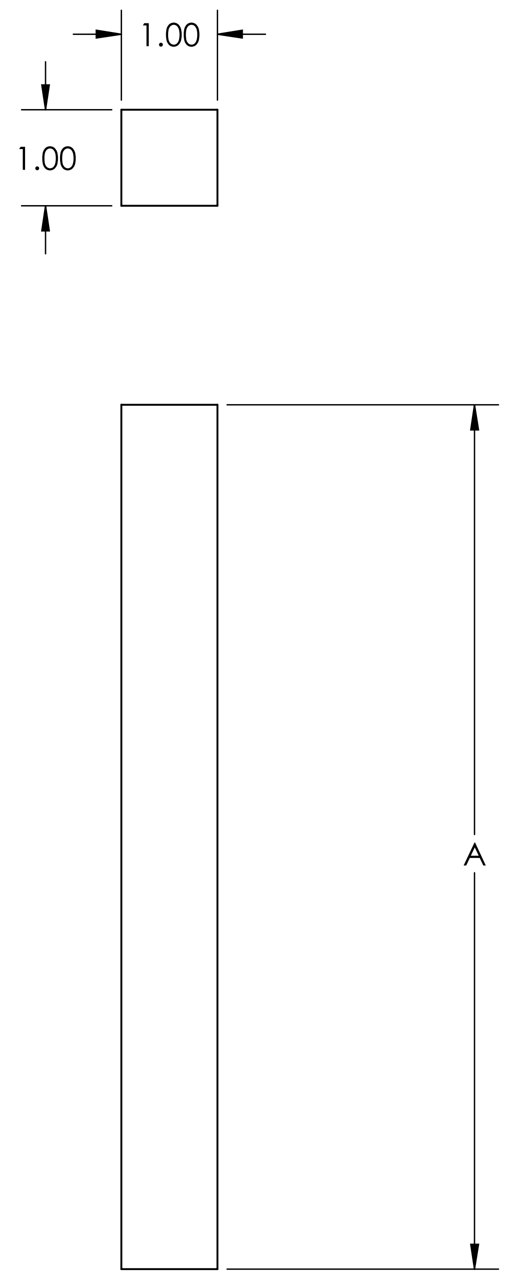
Cal Poly Mechanical Engineering	Senior Project	Part #N/A	Title: Left Wing		Drawn by: Andrew Nott
ME 428/429/430	RSVP Spaceship	Revision: 1.0	Date: 01/29/20	Scale: 1:12	Checked by: Taylor Chavez

NOTES
UNLESS OTHERWISE SPECIFIED
1. ALL DIMENSIONS IN INCHES
2. TOLERANCES:
X = ±.1
X.X = ±.05
X.XX = ±.01
ANGLES = ±2°



ITEM NO.	PART NUMBER	MATERIAL	QTY.
12121	1x1 9in	1x1 Square Dowel Rod	2
12122	1x1 11in	1x1 Square Dowel Rod	4
12123	1x1 14in	1x1 Square Dowel Rod	1
12124	1x1 15.5in	1x1" Square Dowel Rod	1
12125	1x1 19.5in	1x1 Square Dowel Rod	1
12126	1x1 22in	1x1 Square Dowel Rod	1
12127	1x1 36in	1x1 Square Dowel Rod	2
12128	Vertical Beam	1x1 Square Dowel Rod	3
12131	Wing Structure 1	1/4" MDF	1
12132	Wing Structure 2	1/4" MDF	1
12133	Wing Structure 3	1/4" MDF	1
12134	Wing Structure 4	1/4" MDF	1
12135	Wing Structure 5	1/4" MDF	1
12136	Wing Structure 6	1/4" MDF	1
12137	Wing Structure 7	1/4" MDF	1
12138	Wing Structure 8	1/4" MDF	1
12139	Wing Structure 9	1/4" MDF	1
12141	Wing Base (Front)	1/4" MDF	1
12142	Wing Base (Rear)	1/4" MDF	1
13212	Castor	-	1
13121	U Bracket	-	1
13125	Piston Bracket	-	1
13126	Flat Square Bracket	-	4
13242	Hinge	-	2

Cal Poly Mechanical Engineering ME 428/429/430	Senior Project	Part #N/A	Title: Right Wing	Drawn by: Andrew Nott
	RSVP Spaceship	Revision: 1.0	Date: 01/29/20 / Scale: 1:12	Checked by: Taylor Chavez

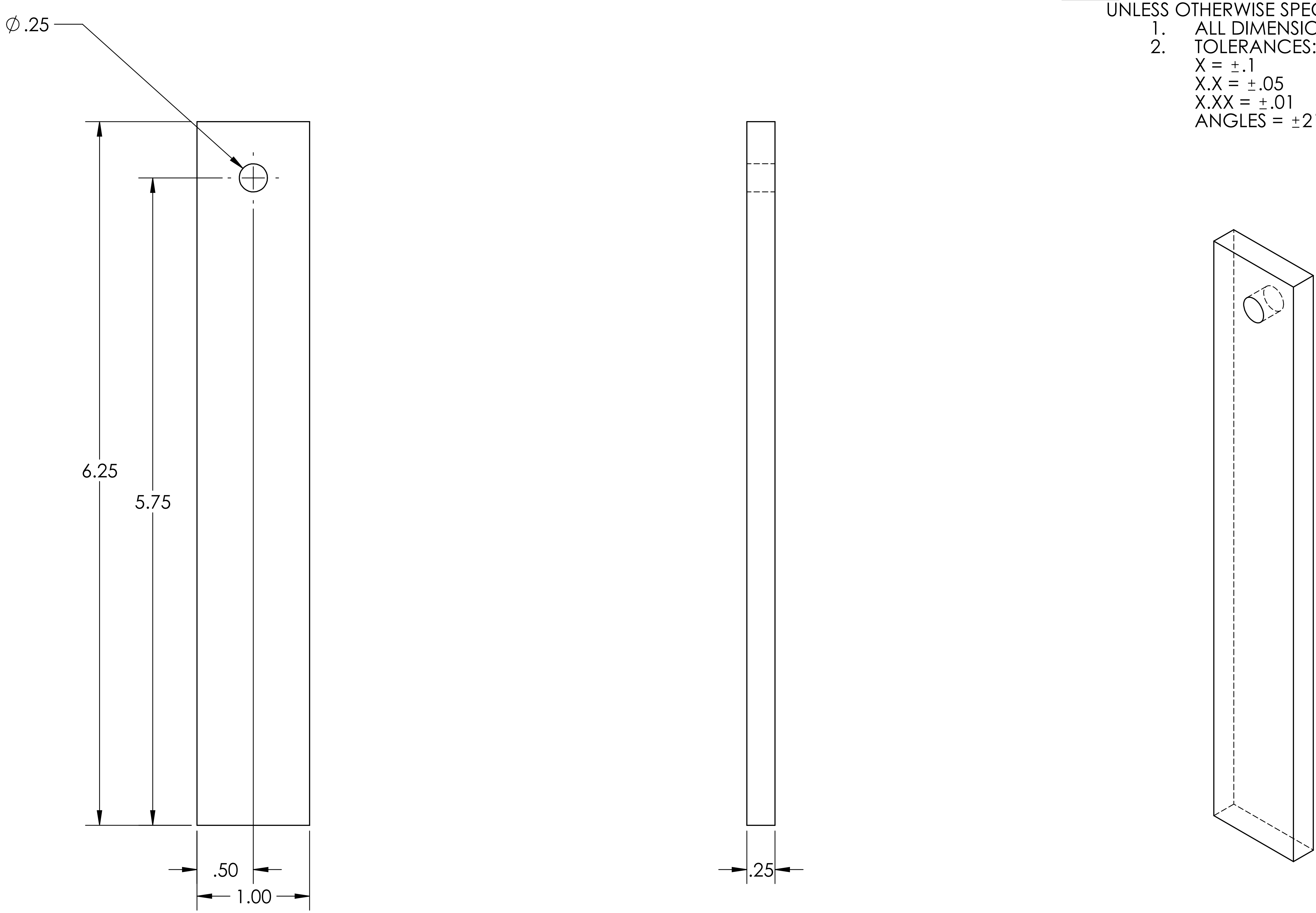


NOTES
UNLESS OTHERWISE SPECIFIED
1. ALL DIMENSIONS IN INCHES
2. TOLERANCES:
X = ±.1
X.X = ±.05
X.XX = ±.01
ANGLES = ±2°

PART #	LENGTH A (in)	QTY
12121	4.25	2
12122	9	4
12123	11	8
12124	12	2
12125	14	2
12126	15.5	2
12127	19.5	2
12128	22	4
12129	36	4

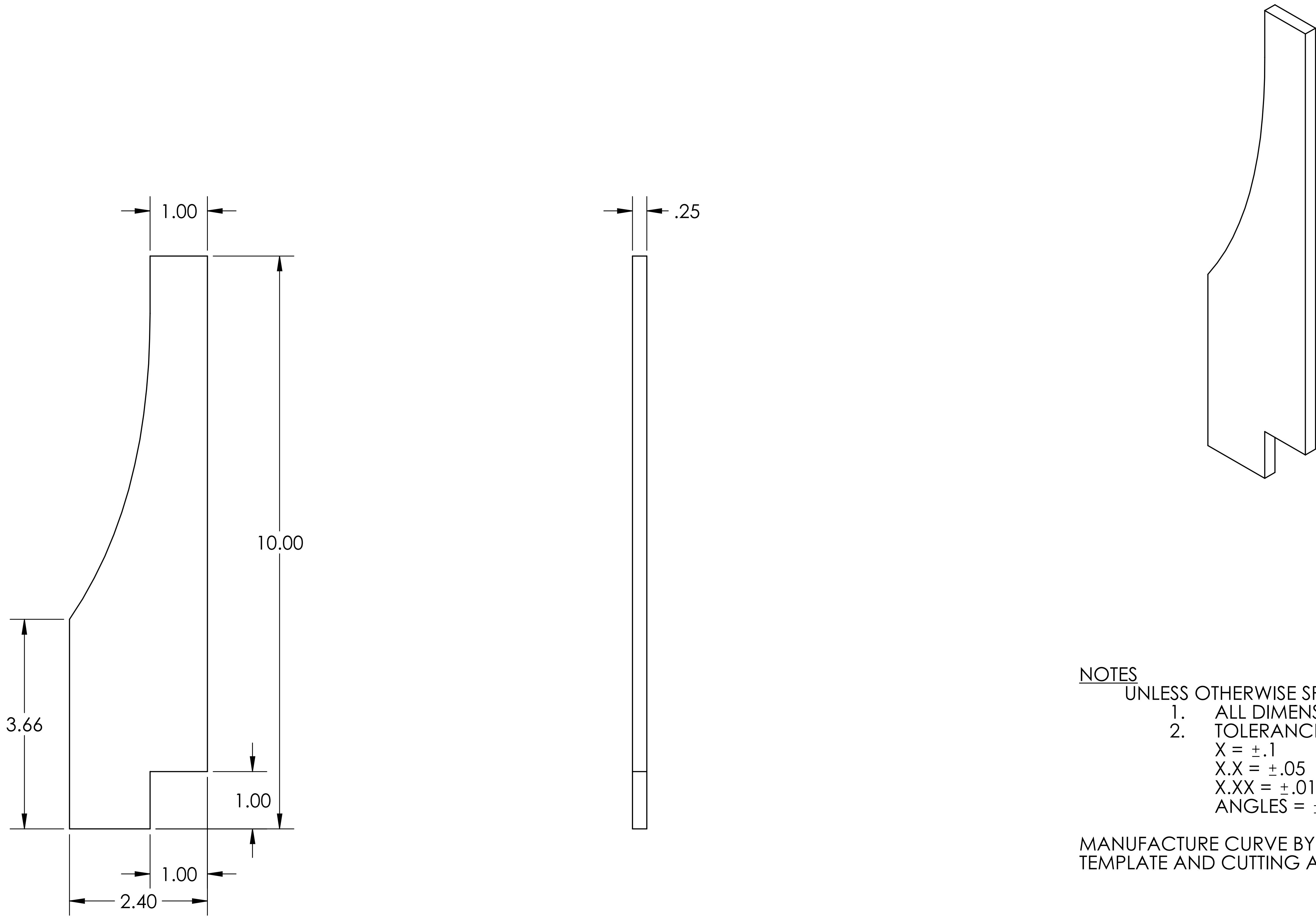
Material
1"x1" Wood

Cal Poly Mechanical Engineering	Senior Project	Part # VARIES	Title: Fuselage 1x1 Cut Sheet		Drawn by: Andrew Nott
ME 428/429/430	RSVP Spaceship	Revision: 1.0	Date: 01/28/20	Scale: N/A	Checked by: Taylor Chavez



NOTES
UNLESS OTHERWISE SPECIFIED
1. ALL DIMENSIONS IN INCHES
2. TOLERANCES:
X = ±.1
X.X = ±.05
X.XX = ±.01
ANGLES = ±2°

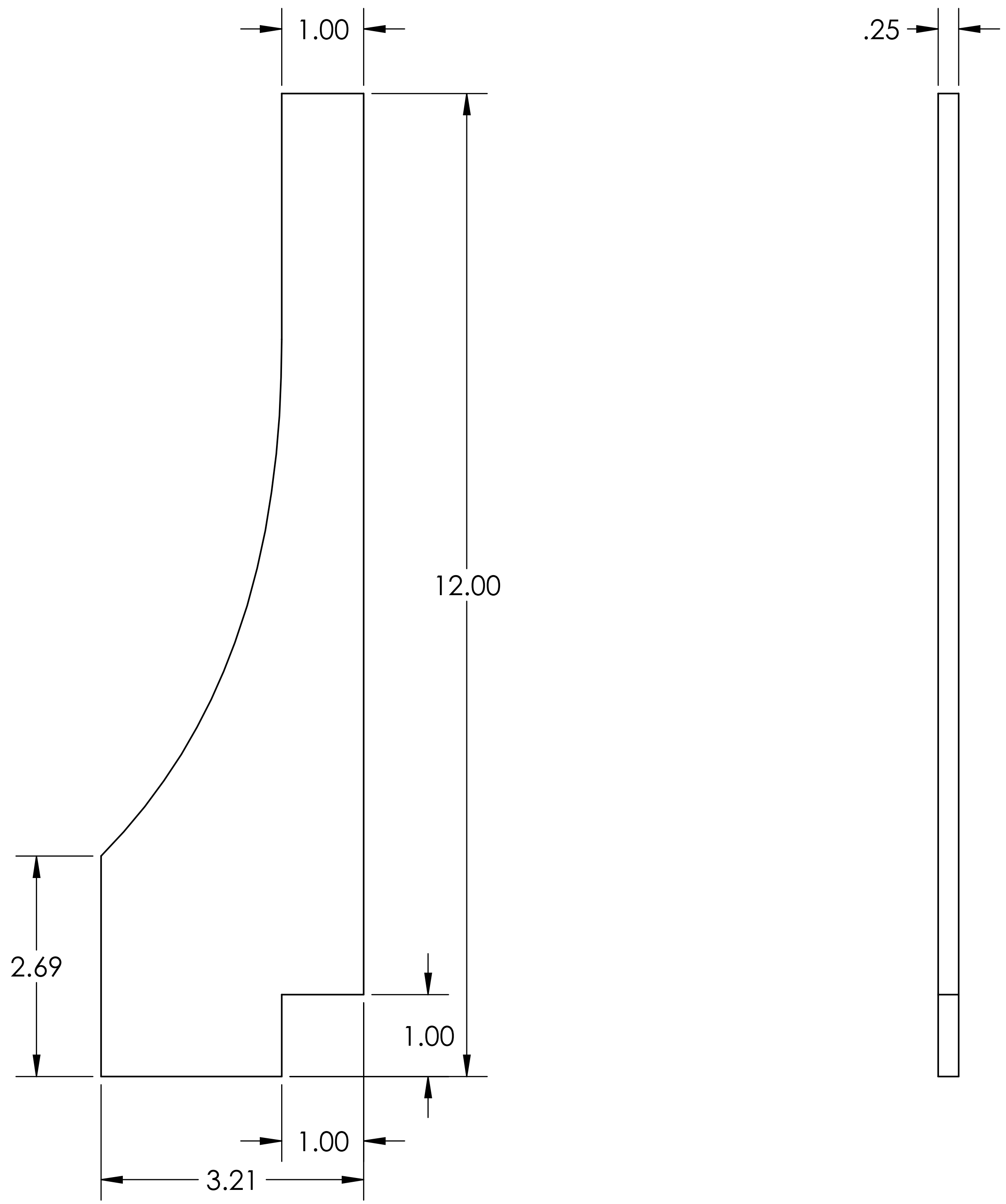
Material	Cal Poly Mechanical Engineering	Senior Project	Part #12128	Title: Vertical Beam		Drawn by: Andrew Nott
1/4" MDF	ME 428/429/430	RSVP Spaceship	Revision: 1.0	Date: 02/25/20	Scale: 1:1	Checked by: Taylor Chavez

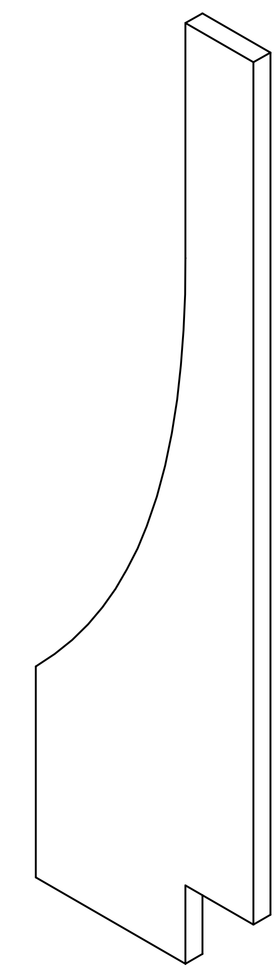


NOTES
UNLESS OTHERWISE SPECIFIED
1. ALL DIMENSIONS IN INCHES
2. TOLERANCES:
X = ±.1
X.X = ±.05
X.XX = ±.01
ANGLES = ±2°

MANUFACTURE CURVE BY PRINTING FULL SCALE TEMPLATE AND CUTTING ALONG THE LINES

Material	Cal Poly Mechanical Engineering	Senior Project	Part #12131	Title: Wing Structure 1		Drawn by: Andrew Nott
1/4" MDF	ME 428/429/430	RSVP Spaceship	Revision: 1.0	Date: 01/29/20	Scale: 1:2	Checked by: Taylor Chavez

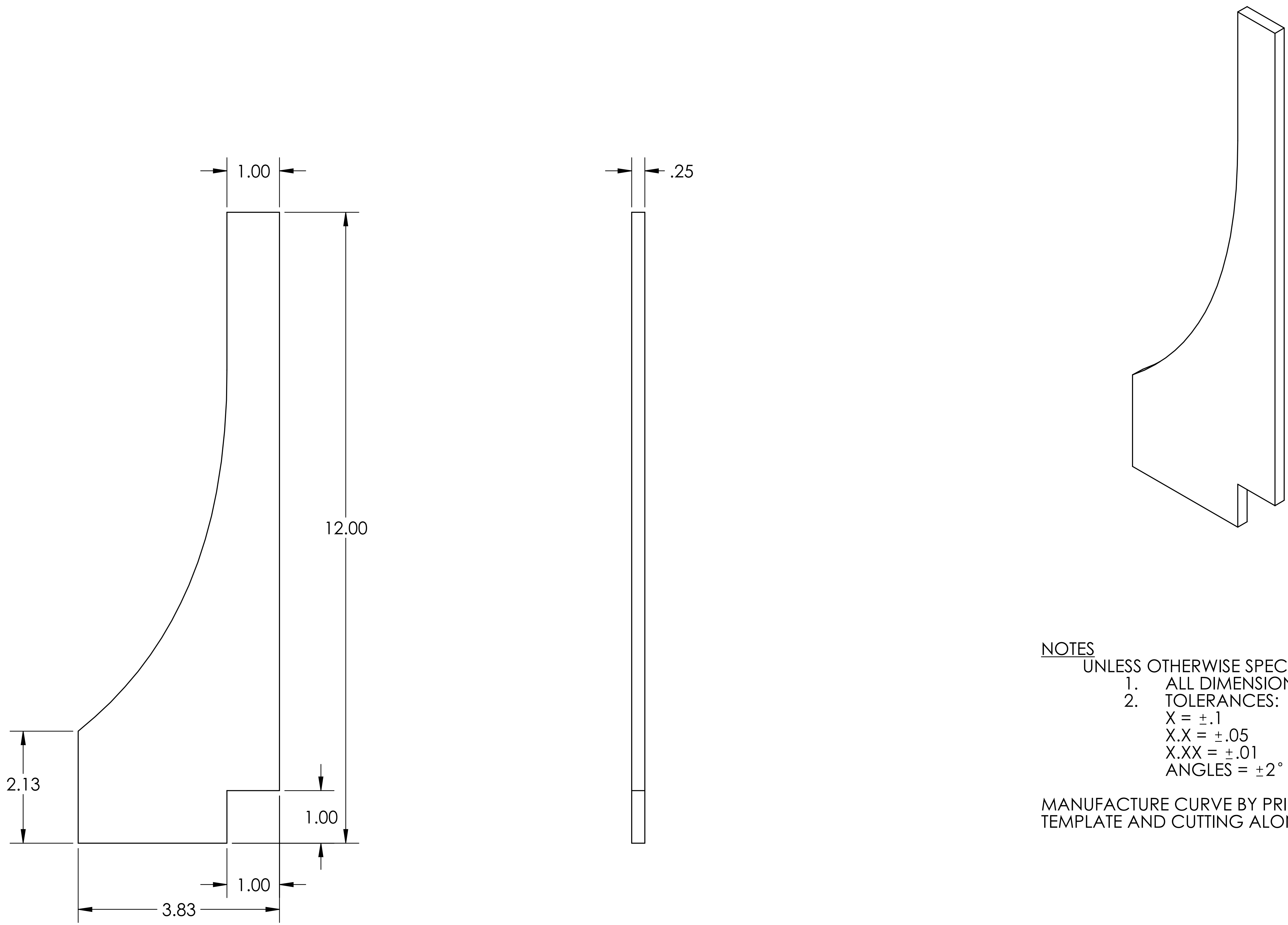




NOTES
UNLESS OTHERWISE SPECIFIED
1. ALL DIMENSIONS IN INCHES
2. TOLERANCES:
X = ±.1
X.X = ±.05
X.XX = ±.01
ANGLES = ±2°

MANUFACTURE CURVE BY PRINTING FULL SCALE TEMPLATE AND CUTTING ALONG THE LINES

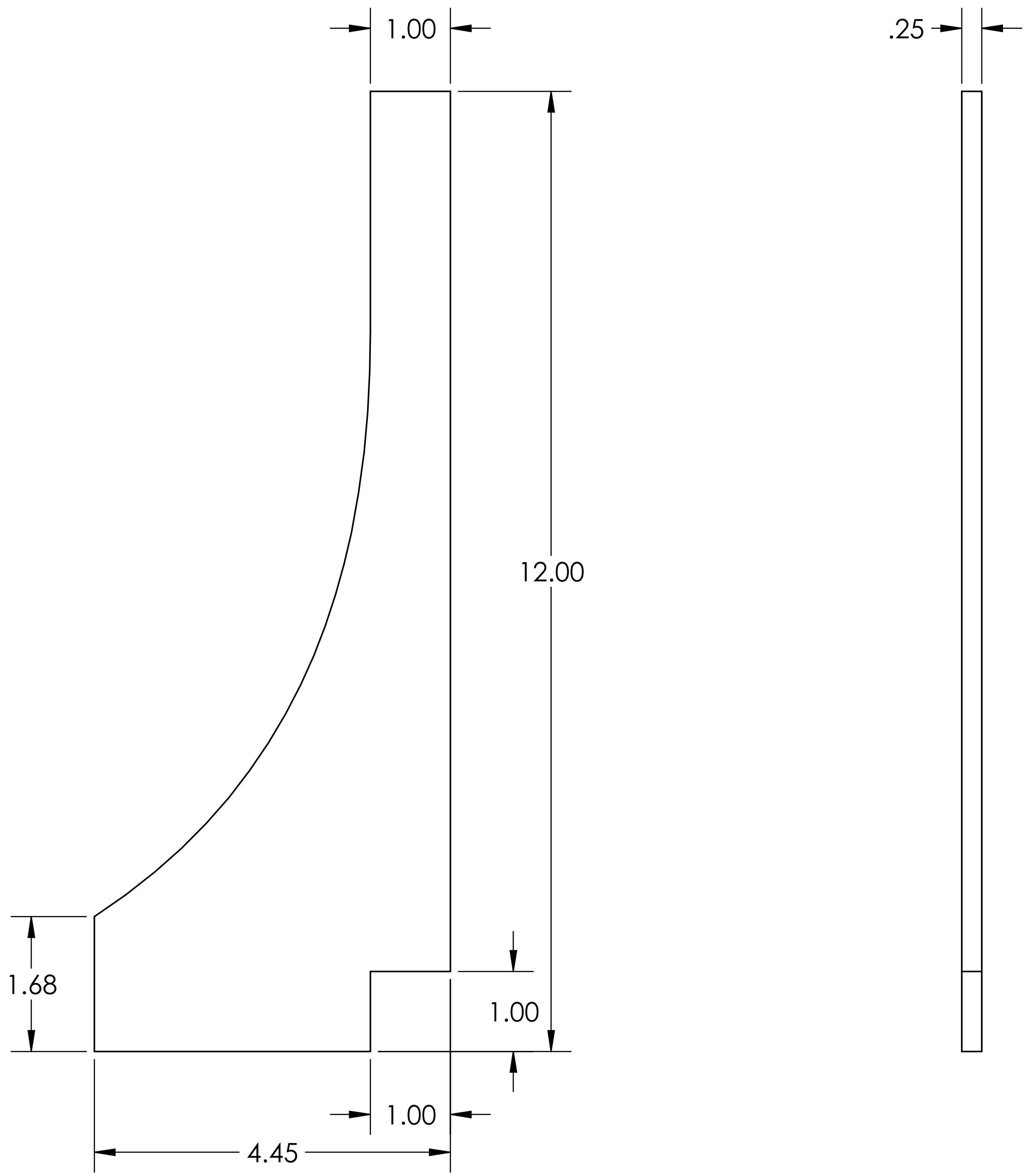
Material	Cal Poly Mechanical Engineering	Senior Project	Part #12132	Title: Wing Structure 2		Drawn by: Andrew Nott
1/4" MDF	ME 428/429/430	RSVP Spaceship	Revision: 1.0	Date: 01/29/20	Scale: 1:2	Checked by: Taylor Chavez

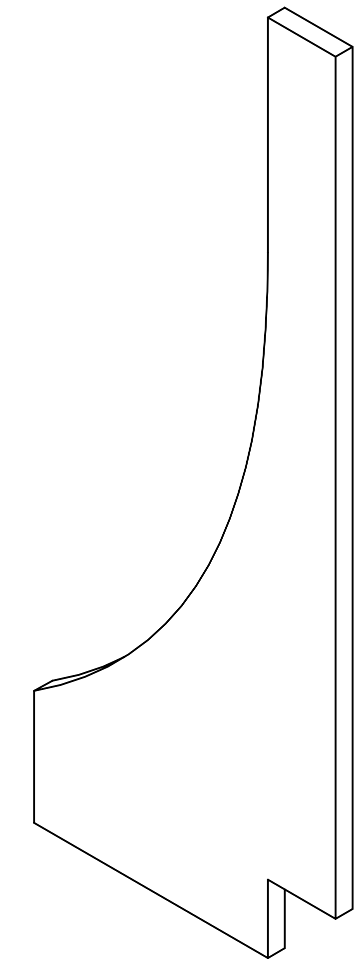


NOTES
UNLESS OTHERWISE SPECIFIED
1. ALL DIMENSIONS IN INCHES
2. TOLERANCES:
X = ±.1
X.X = ±.05
X.XX = ±.01
ANGLES = ±2°

MANUFACTURE CURVE BY PRINTING FULL SCALE TEMPLATE AND CUTTING ALONG THE LINES

Material	Cal Poly Mechanical Engineering	Senior Project	Part #12133	Title: Wing Structure 3		Drawn by: Andrew Nott
1/4" MDF	ME 428/429/430	RSVP Spaceship	Revision: 1.0	Date: 01/29/20	Scale: 1:2	Checked by: Taylor Chavez





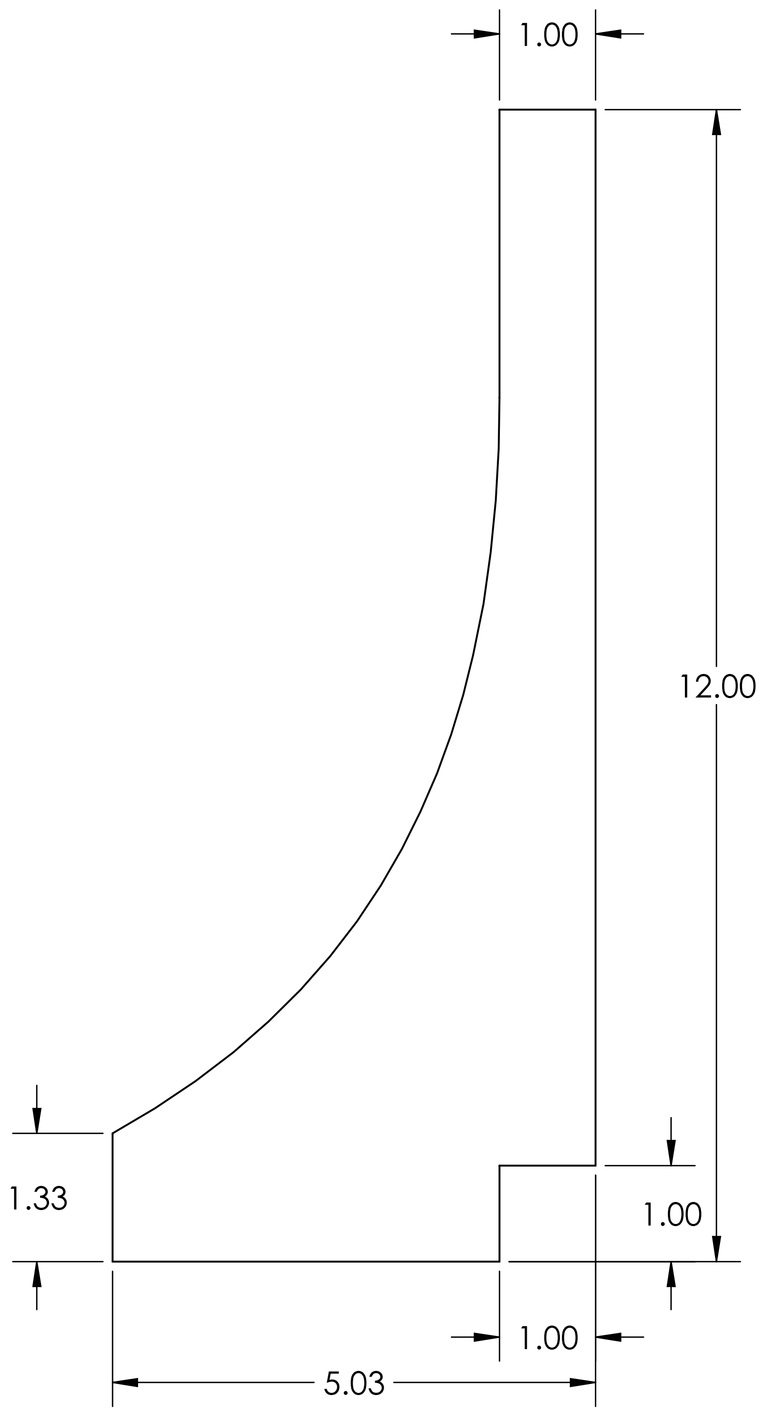
<u>NOTES</u>

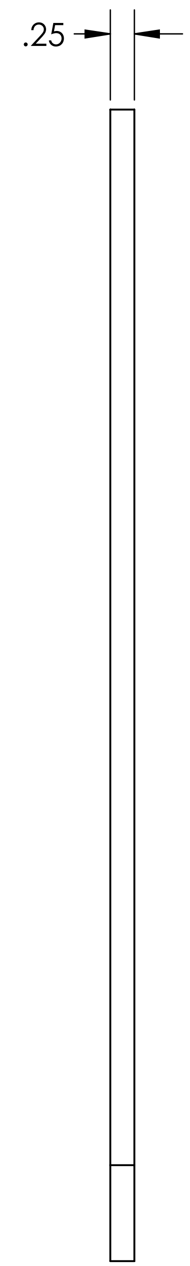
UNLESS OTHERWISE SPECIFIED

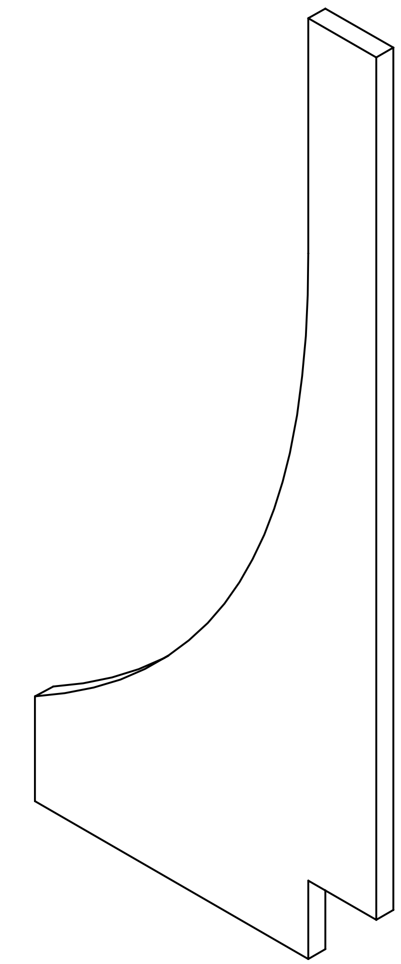
1. ALL DIMENSIONS IN INCHES
2. TOLERANCES:
   X = ±.1
   X.X = ±.05
   X.XX = ±.01
   ANGLES = ±2°

MANUFACTURE CURVE BY PRINTING FULL SCALE TEMPLATE AND CUTTING ALONG THE LINES

Material	Cal Poly Mechanical Engineering	Senior Project	Part #12134	Title: Wing Structure 4		Drawn by: Andrew Nott
1/4" MDF	ME 428/429/430	RSVP Spaceship	Revision: 1.0	Date: 01/29/20	Scale: 1:2	Checked by: Taylor Chavez



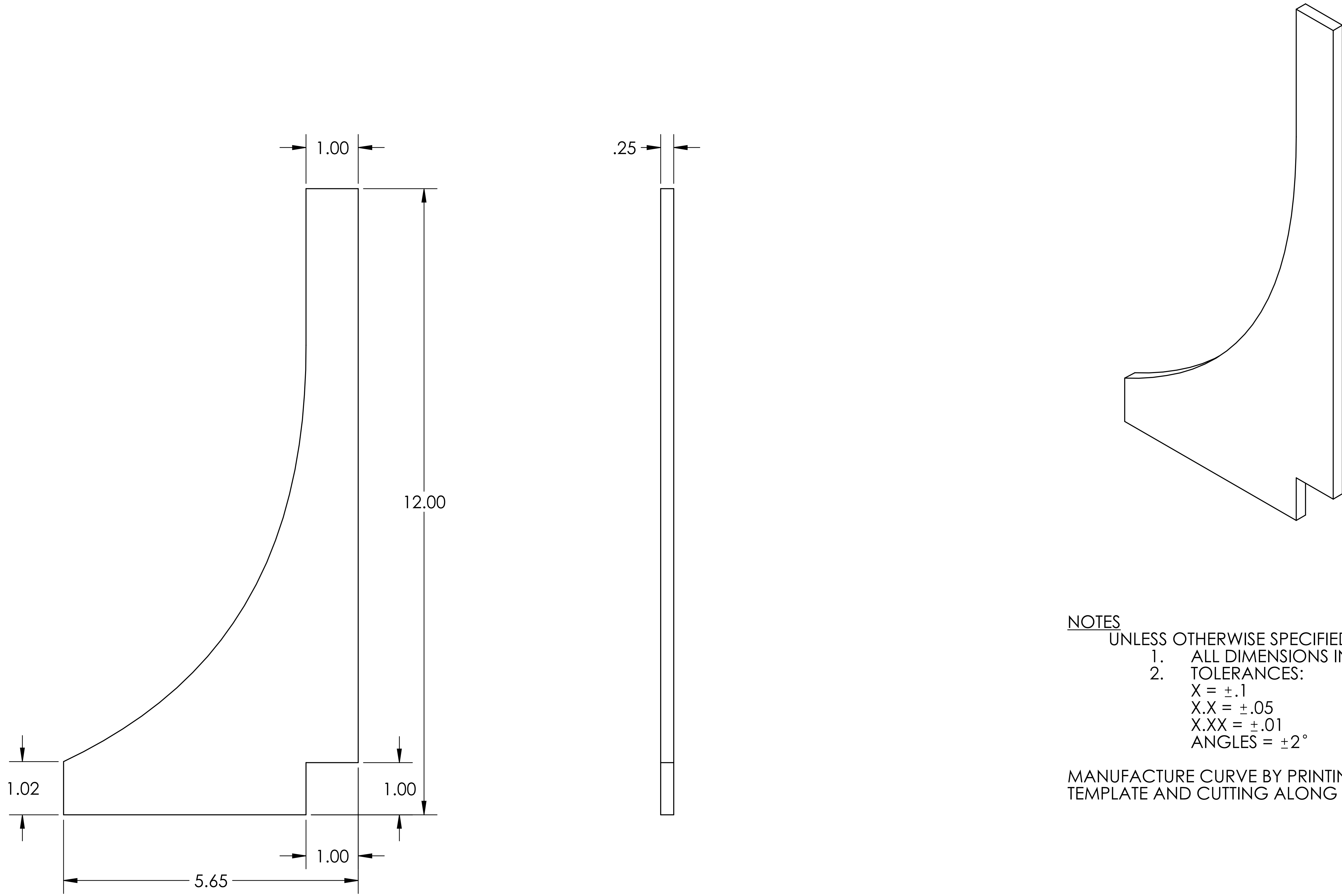




NOTES
UNLESS OTHERWISE SPECIFIED
1. ALL DIMENSIONS IN INCHES
2. TOLERANCES:
X = ±.1
X.X = ±.05
X.XX = ±.01
ANGLES = ±2°

MANUFACTURE CURVE BY PRINTING FULL SCALE TEMPLATE AND CUTTING ALONG THE LINES

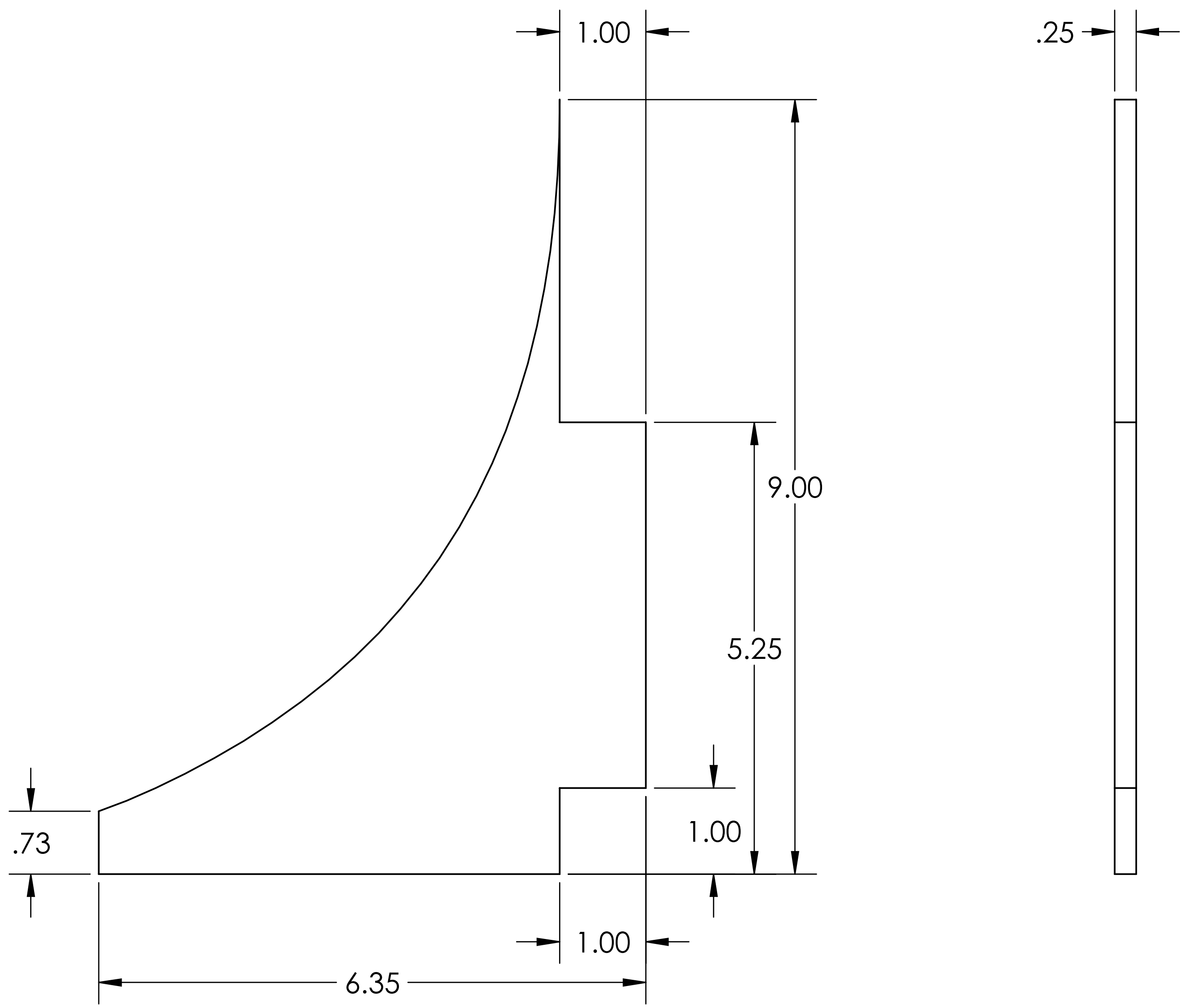
Material	Cal Poly Mechanical Engineering	Senior Project	Part #12135	Title: Wing Structure 5		Drawn by: Andrew Nott
1/4" MDF	ME 428/429/430	RSVP Spaceship	Revision: 1.0	Date: 01/29/20	Scale: 1:2	Checked by: Taylor Chavez

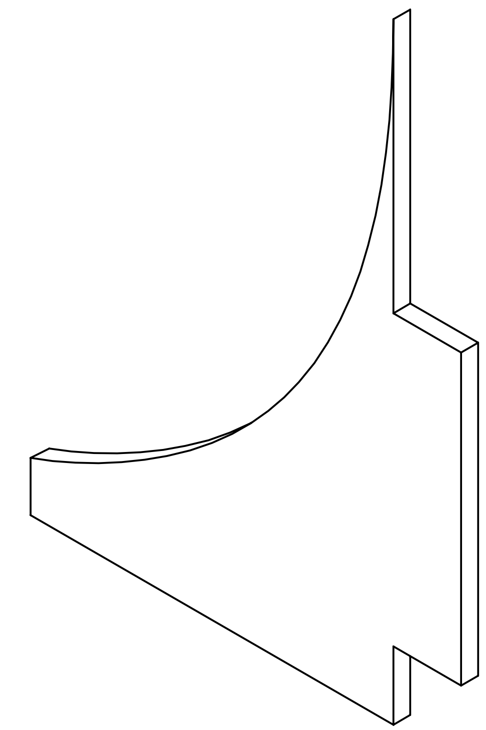


NOTES
UNLESS OTHERWISE SPECIFIED
1. ALL DIMENSIONS IN INCHES
2. TOLERANCES:
X = ±.1
X.X = ±.05
X.XX = ±.01
ANGLES = ±2°

MANUFACTURE CURVE BY PRINTING FULL SCALE TEMPLATE AND CUTTING ALONG THE LINES

Material 1/4" MDF	Cal Poly Mechanical Engineering ME 428/429/430	Senior Project	Part #12136	Title: Wing Structure 6	Drawn by: Andrew Nott
		RSVP Spaceship	Revision: 1.0	Date: 01/29/20 Scale: 1:2	Checked by: Taylor Chavez

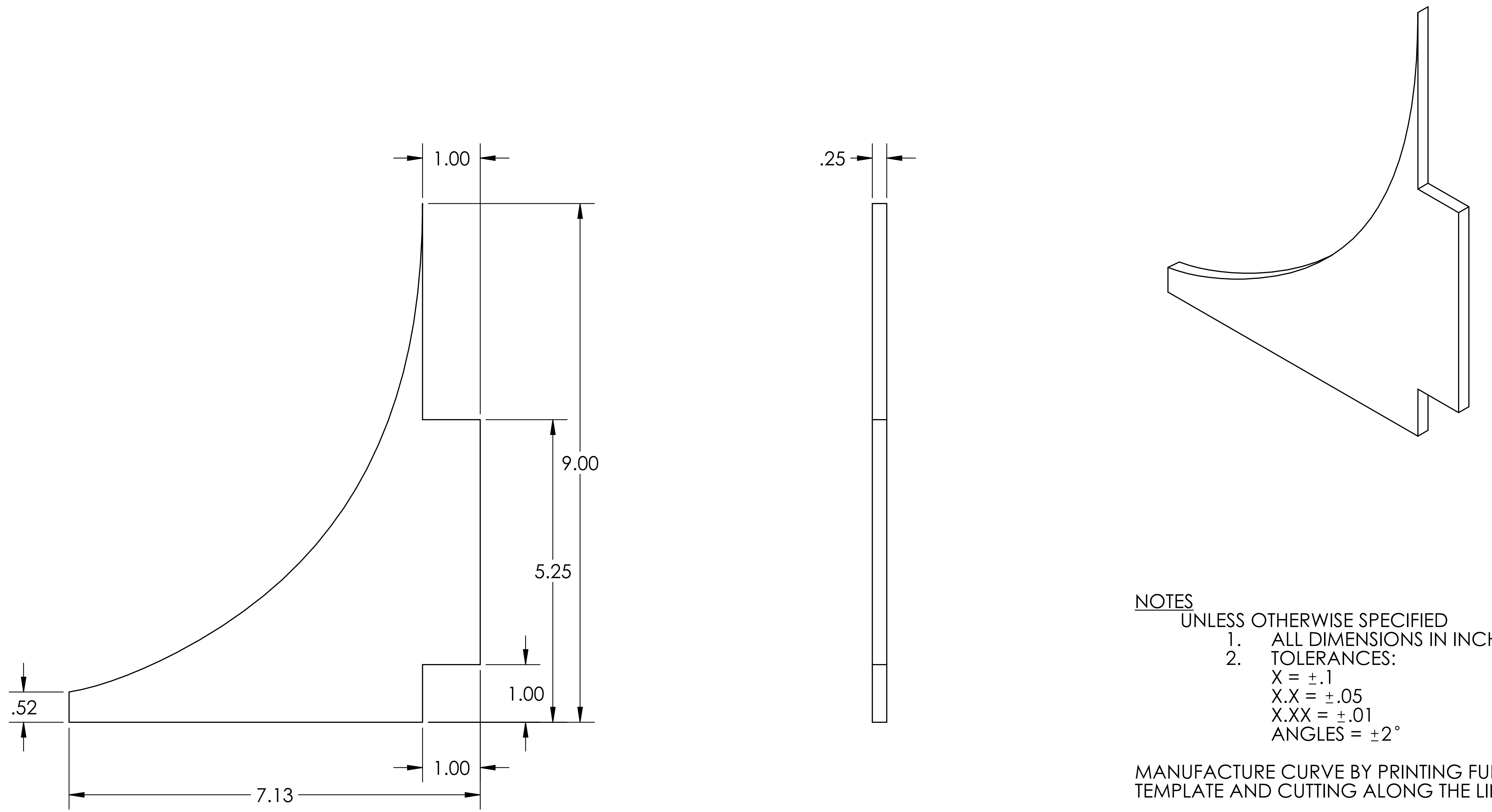




NOTES
UNLESS OTHERWISE SPECIFIED
1. ALL DIMENSIONS IN INCHES
2. TOLERANCES:
X = ±.1
X.X = ±.05
X.XX = ±.01
ANGLES = ±2°

MANUFACTURE CURVE BY PRINTING FULL SCALE TEMPLATE AND CUTTING ALONG THE LINES

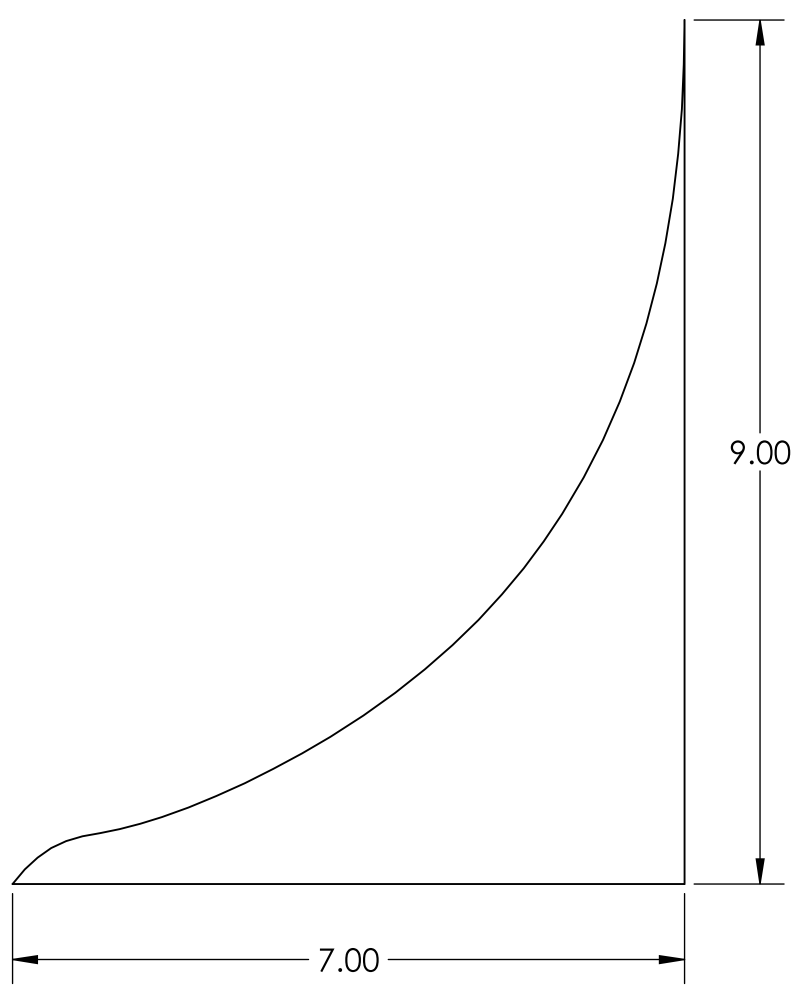
Material	Cal Poly Mechanical Engineering	Senior Project	Part #12137	Title: Wing Structure 7		Drawn by: Andrew Nott
1/4" MDF	ME 428/429/430	RSVP Spaceship	Revision: 1.0	Date: 01/29/20	Scale: 1:2	Checked by: Taylor Chavez

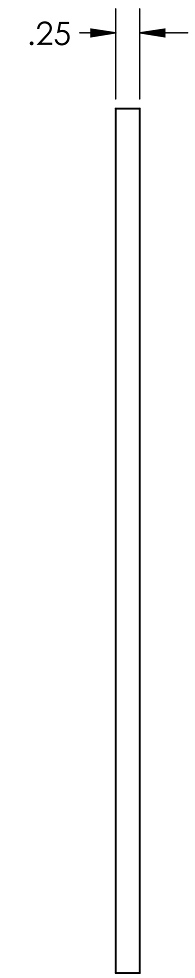


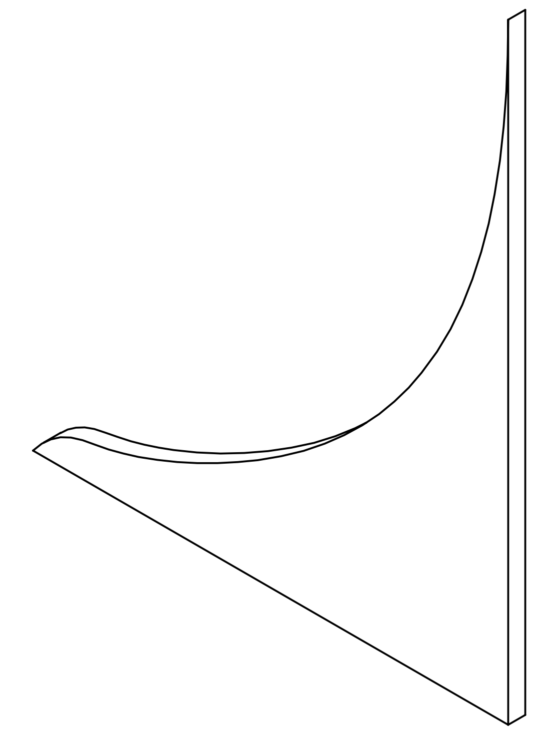
NOTES
UNLESS OTHERWISE SPECIFIED
1. ALL DIMENSIONS IN INCHES
2. TOLERANCES:
X = ±.1
X.X = ±.05
X.XX = ±.01
ANGLES = ±2°

MANUFACTURE CURVE BY PRINTING FULL SCALE TEMPLATE AND CUTTING ALONG THE LINES

Material 1/4" MDF	Cal Poly Mechanical Engineering ME 428/429/430	Senior Project	Part #12138	Title: Wing Structure 8	Drawn by: Andrew Nott
		RSVP Spaceship	Revision: 1.0	Date: 01/29/20 · Scale: 1:2	Checked by: Taylor Chavez



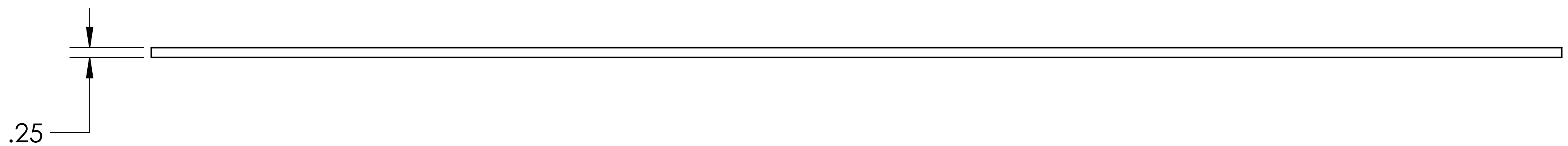


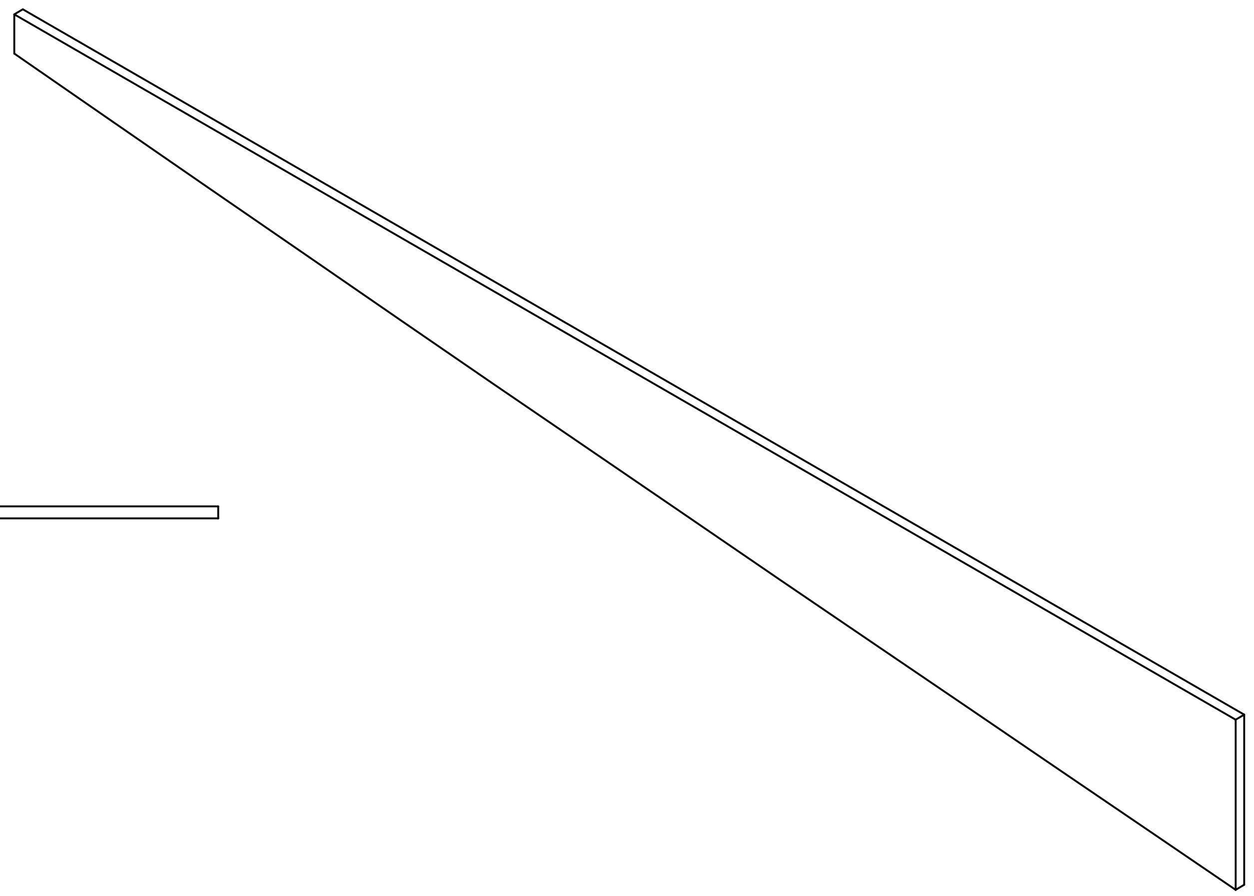


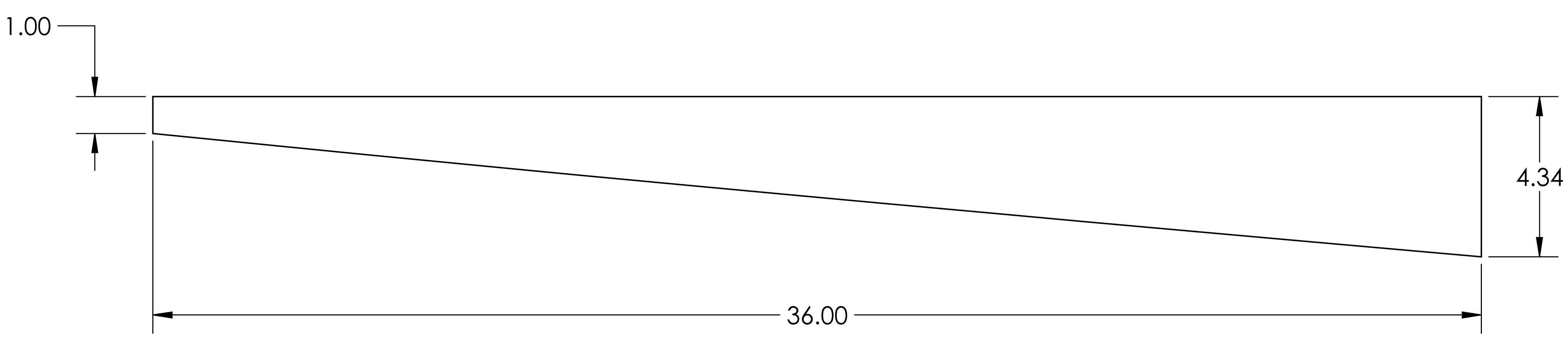
NOTES
UNLESS OTHERWISE SPECIFIED
1. ALL DIMENSIONS IN INCHES
2. TOLERANCES:
X = $\pm$.1
X.X = $\pm$.05
X.XX = $\pm$.01
ANGLES = $\pm 2^\circ$

MANUFACTURE CURVE BY PRINTING FULL SCALE TEMPLATE AND CUTTING ALONG THE LINES

Material	Cal Poly Mechanical Engineering	Senior Project	Part #12139	Title: Wing Structure 9		Drawn by: Andrew Nott
1/4" MDF	ME 428/429/430	RSVP Spaceship	Revision: 1.0	Date: 01/29/20	Scale: 1:2	Checked by: Taylor Chavez



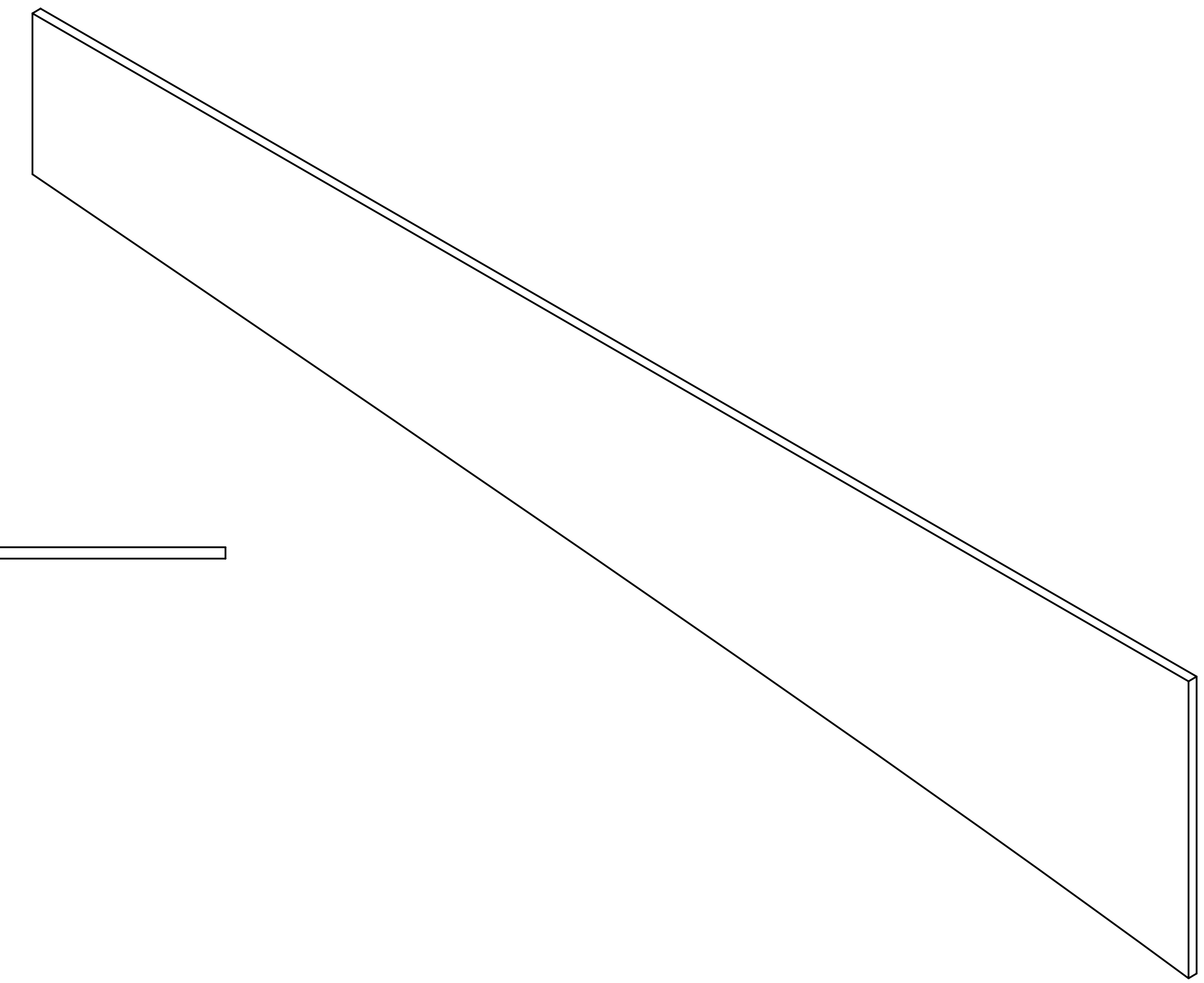


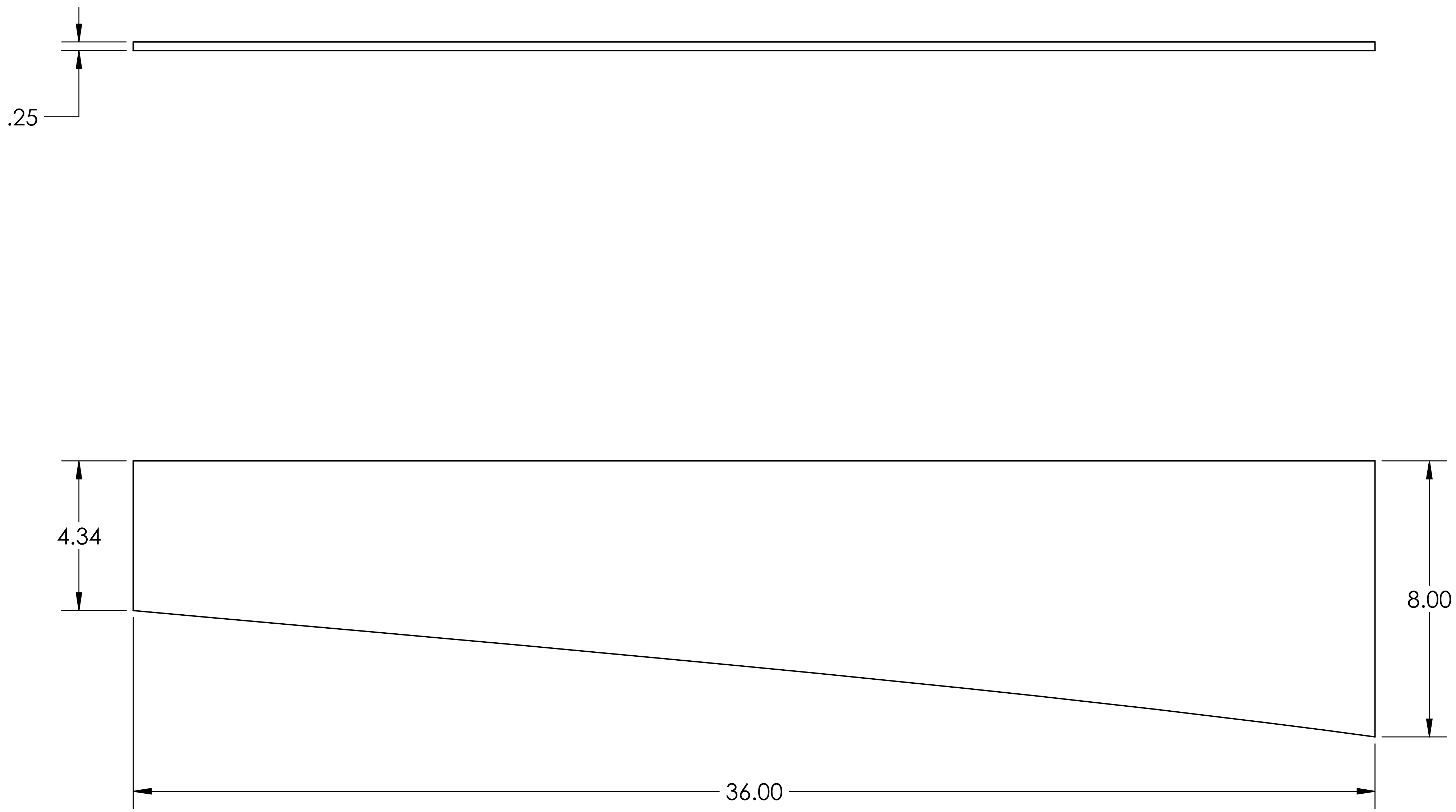


NOTES
UNLESS OTHERWISE SPECIFIED
1. ALL DIMENSIONS IN INCHES
2. TOLERANCES:
X = ±.1
X.X = ±.05
X.XX = ±.01
ANGLES = ±2°

MANUFACTURE CURVE BY PRINTING FULL SCALE TEMPLATE AND CUTTING ALONG THE LINES

Material	Cal Poly Mechanical Engineering	Senior Project	Part #12141	Title: Wing Base (Front)		Drawn by: Andrew Nott
1/4" MDF	ME 428/429/430	RSVP Spaceship	Revision: 1.0	Date: 01/29/20	Scale: 1:4	Checked by: Taylor Chavez

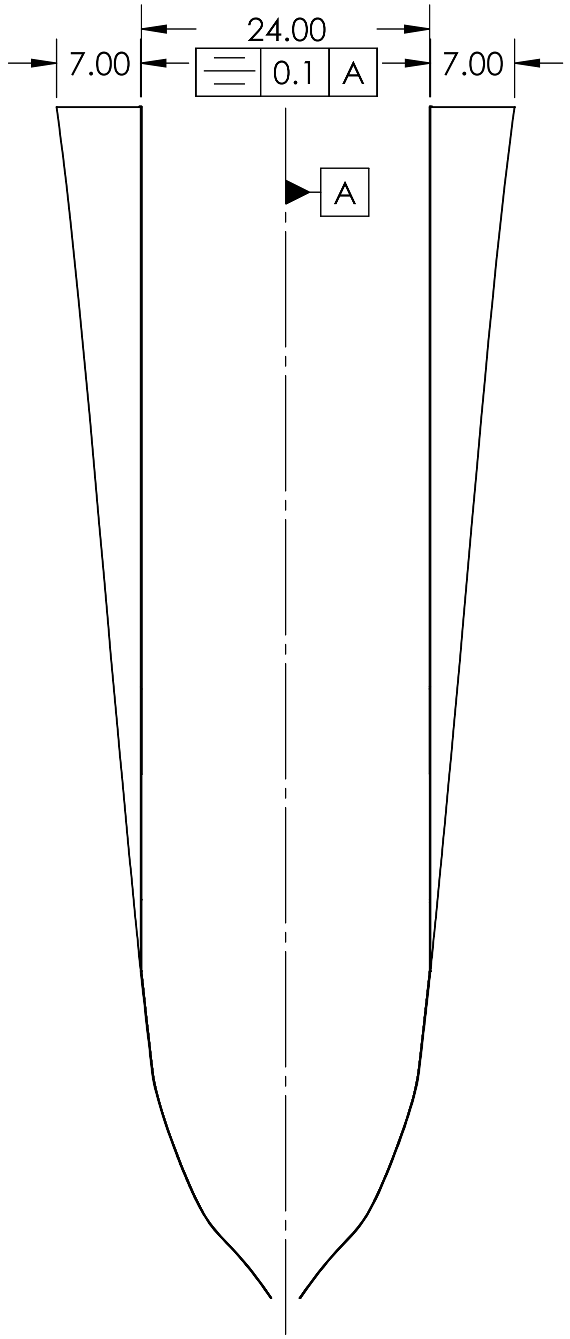


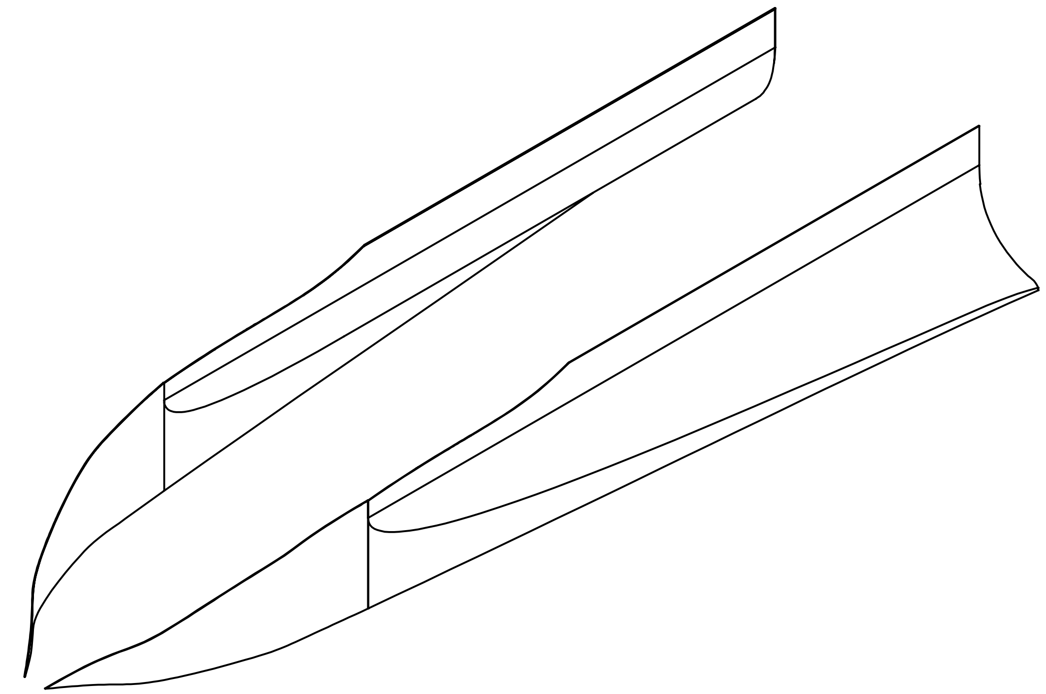


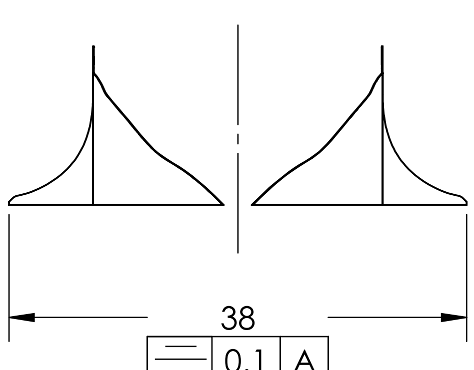
NOTES
UNLESS OTHERWISE SPECIFIED
1. ALL DIMENSIONS IN INCHES
2. TOLERANCES:
X = ±.1
X.X = ±.05
X.XX = ±.01
ANGLES = ±2°

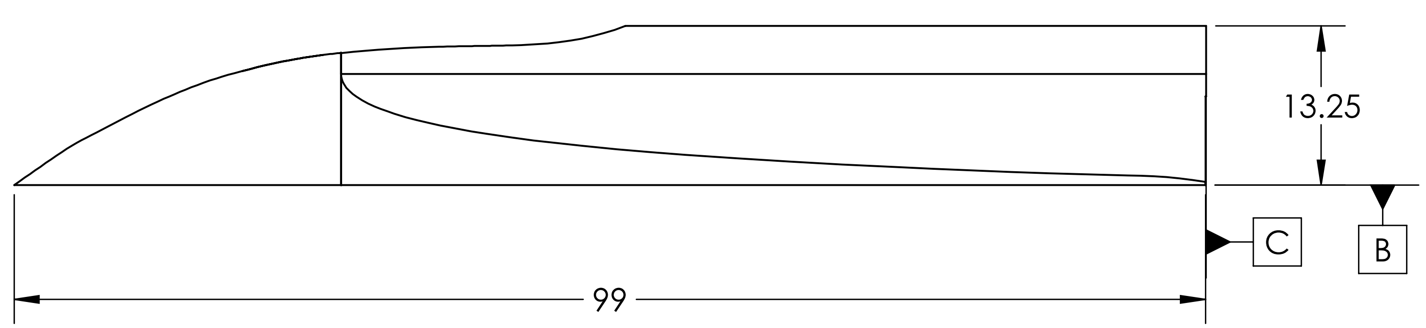
MANUFACTURE CURVE BY PRINTING FULL SCALE TEMPLATE AND CUTTING ALONG THE LINES

Material	Cal Poly Mechanical Engineering	Senior Project	Part #12142	Title: Wing Base (Rear)		Drawn by: Andrew Nott
1/4" MDF	ME 428/429/430	RSVP Spaceship	Revision: 1.0	Date: 01/29/20	Scale: 1:4	Checked by: Taylor Chavez





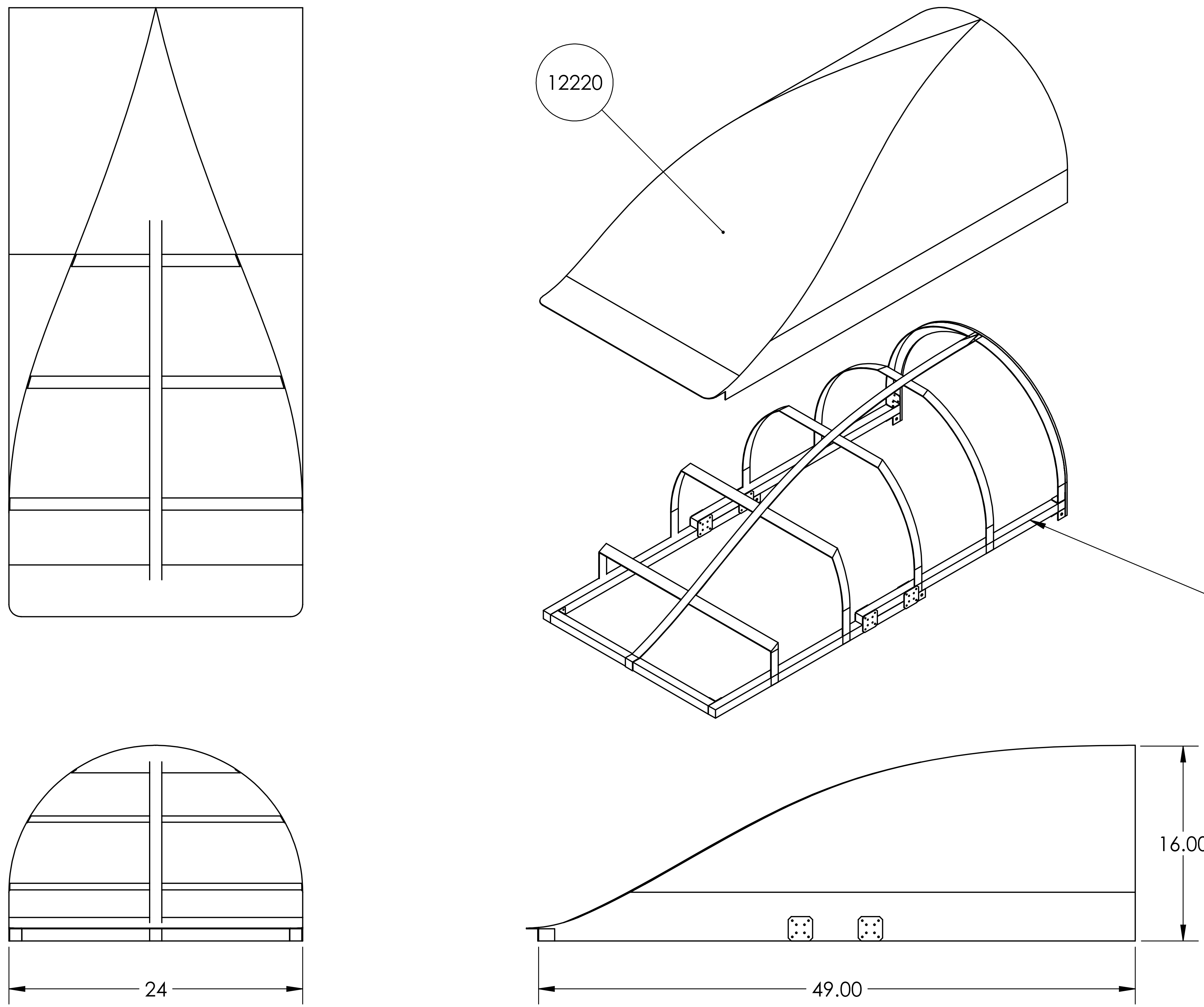




NOTES
UNLESS OTHERWISE SPECIFIED
1. ALL DIMENSIONS IN INCHES
2. TOLERANCES:
X = ±.1
X.X = ±.05
X.XX = ±.01
ANGLES = ±2°

MANUFACTURE BY THERMOFORMING THE PLASTIC ONTO A WIRE MESH ATTACHED TO THE FRAME

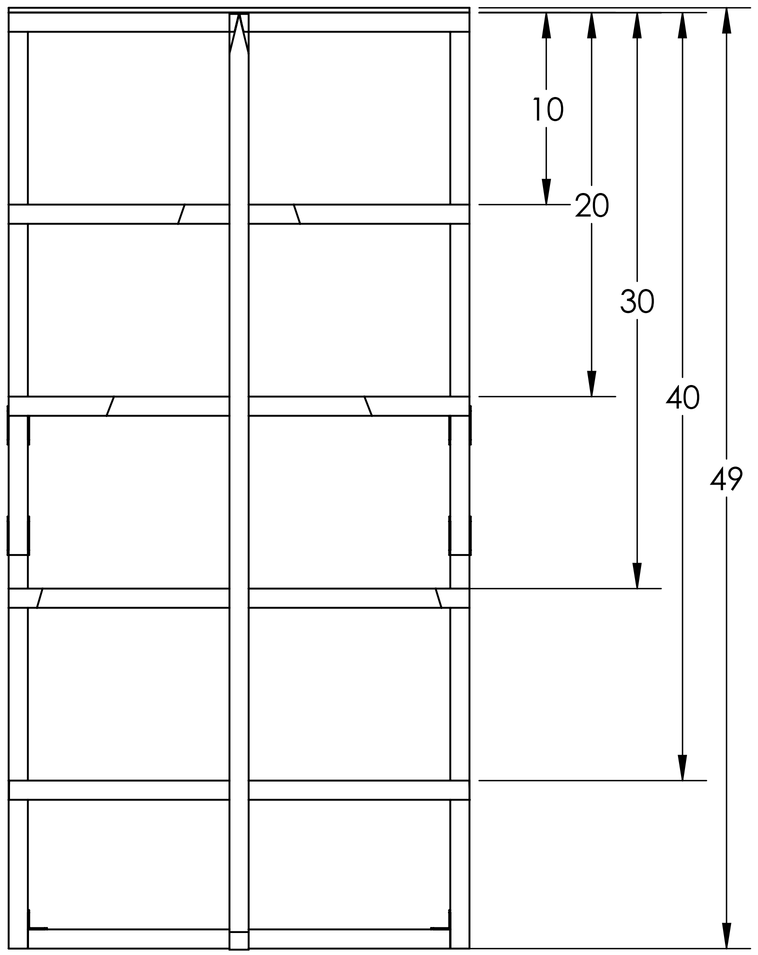
Material Thermoplastic	Cal Poly Mechanical Engineering	Senior Project	Part #12150	Title: Fuselage Shell		Drawn by: Andrew Nott
	ME 428/429/430	RSVP Spaceship	Revision: 1.0	Date: 01/29/20	Scale: 1:16	Checked by: Taylor Chavez



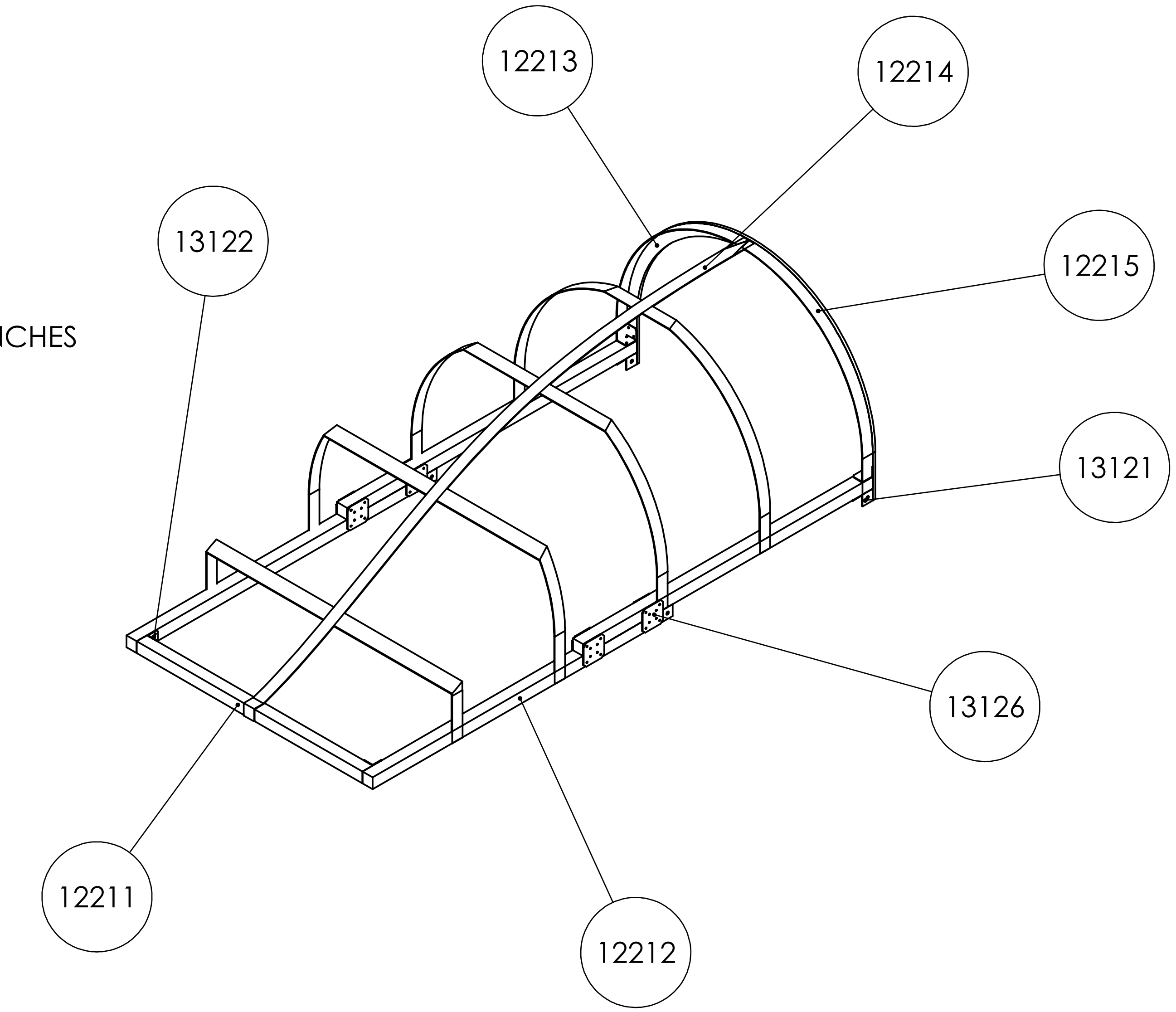
NOTES
UNLESS OTHERWISE SPECIFIED
1. ALL DIMENSIONS IN INCHES
2. TOLERANCES:
X = ±.1
X.X = ±.05
X.XX = ±.01
ANGLES = ±2°

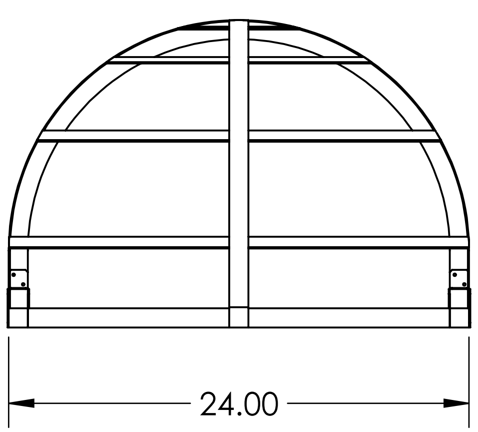
ITEM NO.	PART NUMBER	
12210	Top Hatch Frame	1
12220	Top Hatch Shell	1

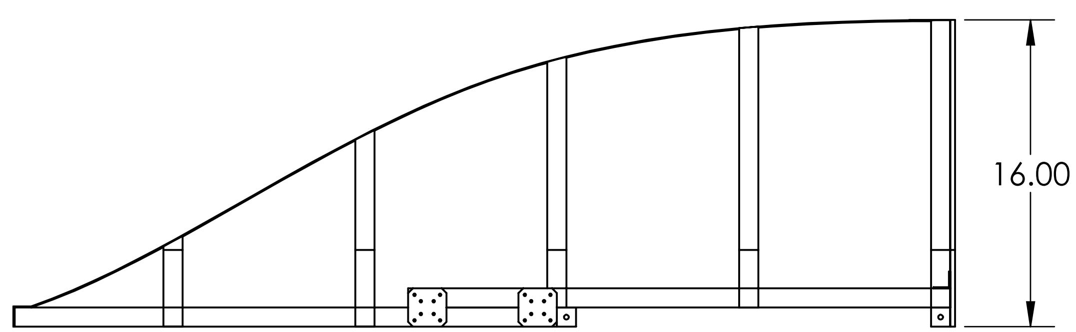
Cal Poly Mechanical Engineering	Senior Project	Part #12200	Title: Top Hatch		Drawn by: Andrew Nott
ME 428/429/430	RSVP Spaceship	Revision: 1.0	Date: 01/29/20	Scale: 1:10	Checked by: Taylor Chavez



NOTES
UNLESS OTHERWISE SPECIFIED
1. ALL DIMENSIONS IN INCHES
2. TOLERANCES:
X = ±.1
X.X = ±.05
X.XX = ±.01
ANGLES = ±2°

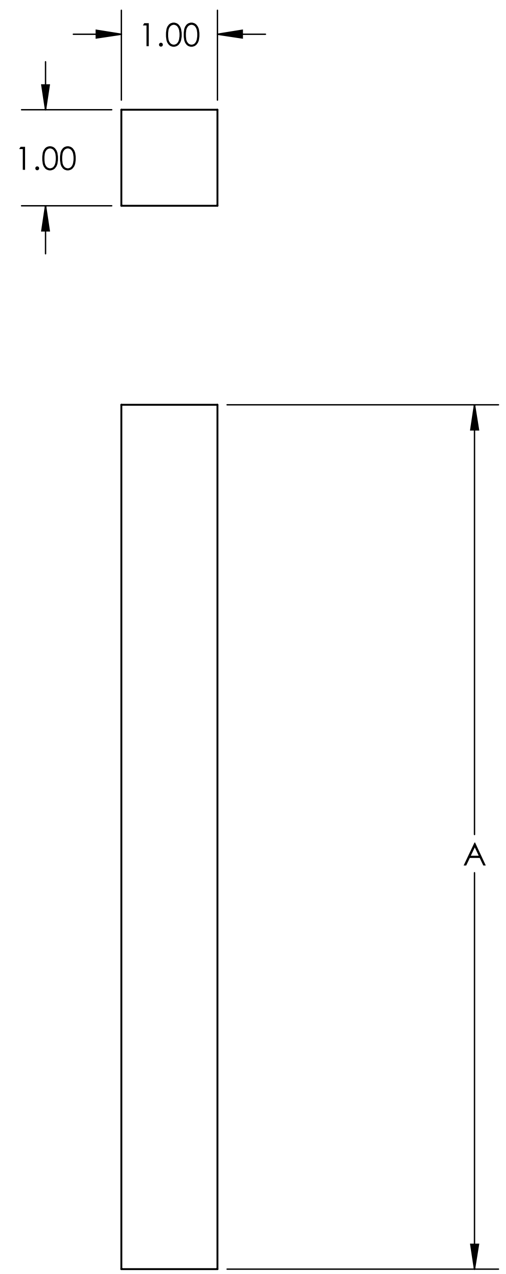






PART #	PART	MATERIAL	QTY.
12211	Top Hatch Front Cross Beam	1x1" Square Dowel Rod	1
12212	1x1 28.25in	1x1" Square Dowel Rod	4
12213	Top Hatch Rear Hoop	1/4" MDF Sheet	1
12214	Shell Center Spline	1/8" Aluminum Strip	1
12215	Shell Cross Splines	1/8" Aluminum Strip	1
13121	U Bracket	-	4
13122	1x1 L Bracket	-	4
13126	Flat Square Bracket	-	8

Cal Poly Mechanical Engineering	Senior Project	Part #12210	Title: Top Hatch Frame		Drawn by: Andrew Nott
ME 428/429/430	RSVP Spaceship	Revision: 1.0	Date: 01/29/20	Scale: 1:10	Checked by: Taylor Chavez



NOTES

UNLESS OTHERWISE SPECIFIED

1. ALL DIMENSIONS IN INCHES
2. TOLERANCES:
   X = ±.1
   X.X = ±.05
   X.XX = ±.01
   ANGLES = ±2°

PART #	LENGTH A (in)	QTY
12211	22	1
12212	28.25	4

Material
1"x1" Wood

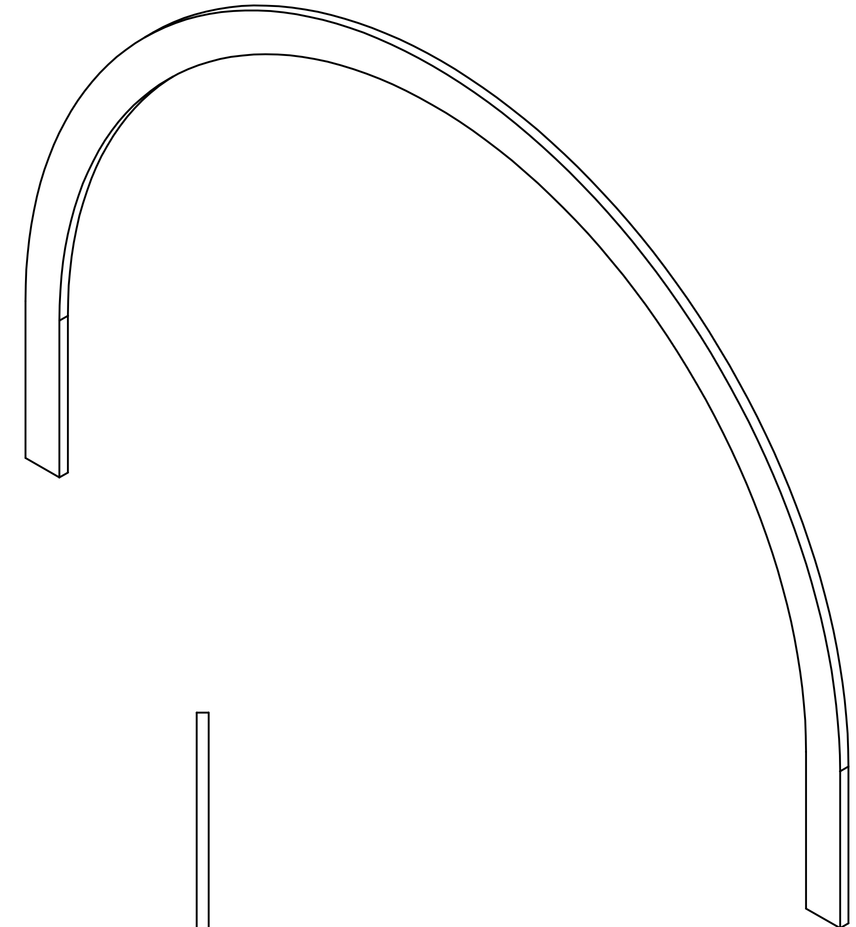
Cal Poly Mechanical Engineering	Senior Project	Part # VARIES	Title: Top Hatch 1x1 Cut Sheet		Drawn by: Andrew Nott
ME 428/429/430	RSVP Spaceship	Revision: 1.0	Date: 01/29/20	Scale: N/A	Checked by: Taylor Chavez

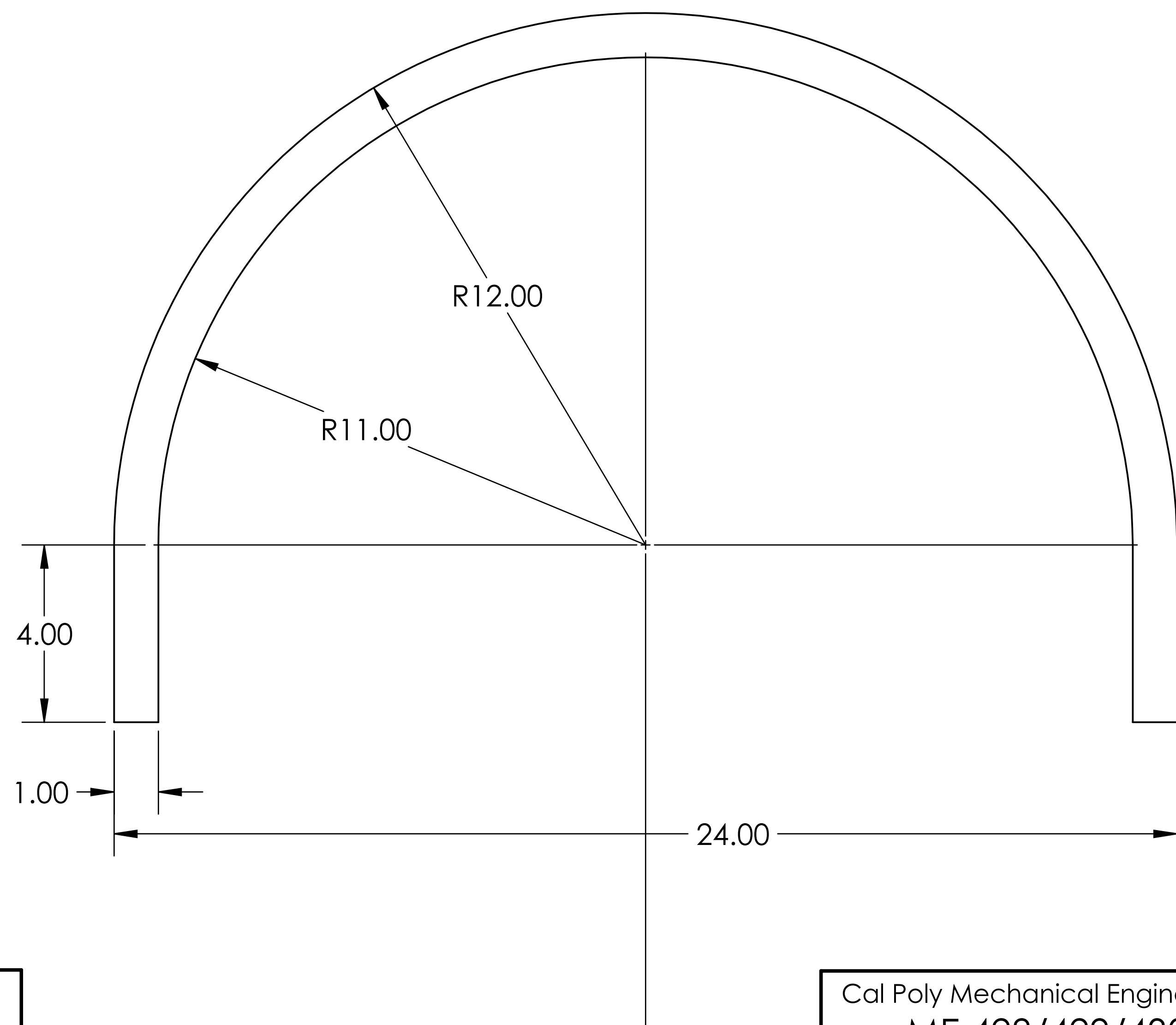
NOTES

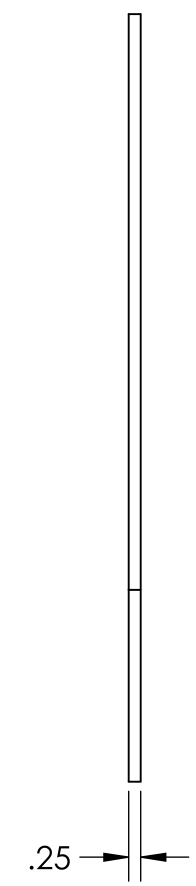
UNLESS OTHERWISE SPECIFIED

1. ALL DIMENSIONS IN INCHES
2. TOLERANCES:
   X = ±.1
   X.X = ±.05
   X.XX = ±.01
   ANGLES = ±2°

MANUFACTURE CURVE BY PRINTING FULL SCALE TEMPLATE AND CUTTING ALONG THE LINES

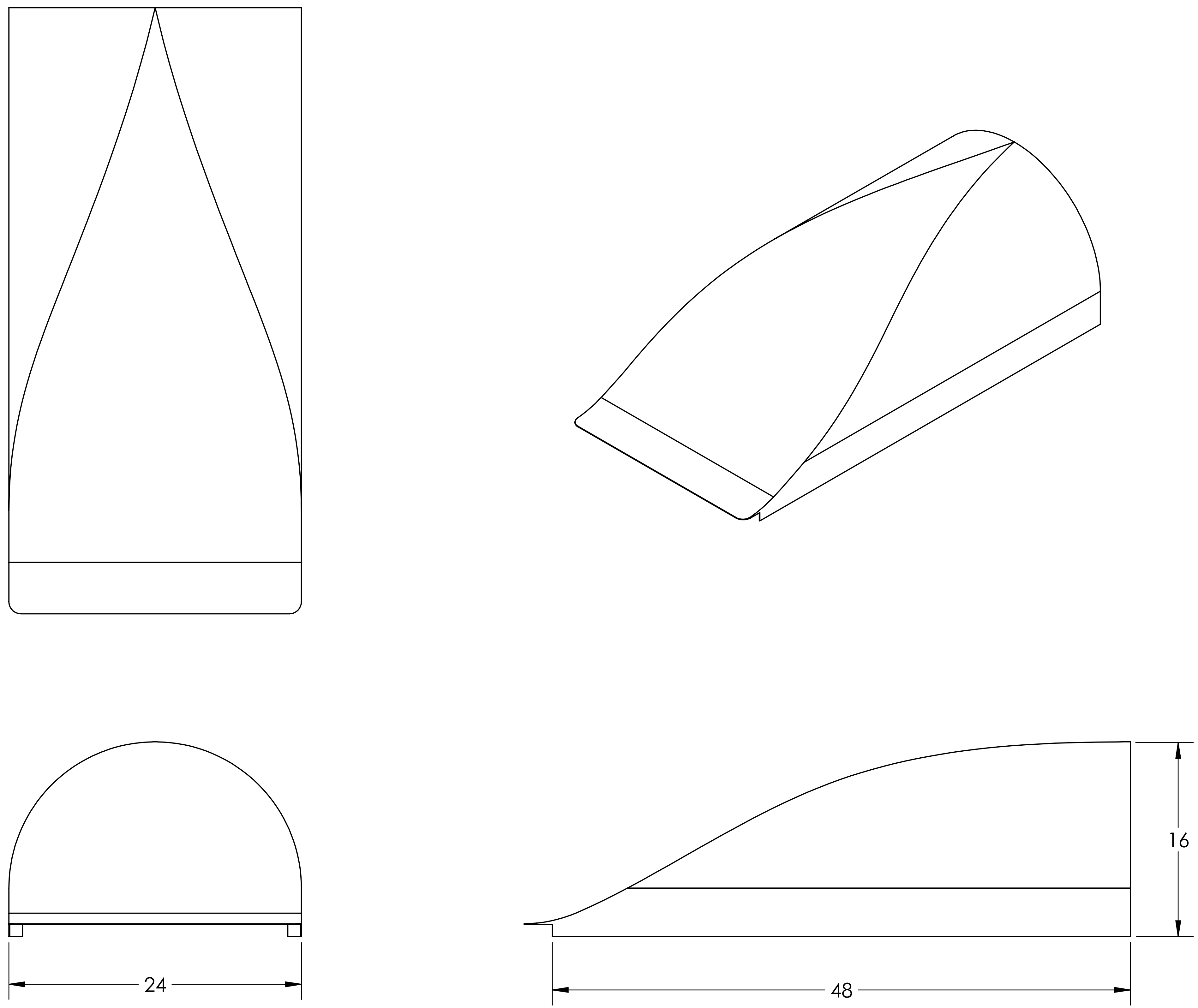






Material
1/4" MDF

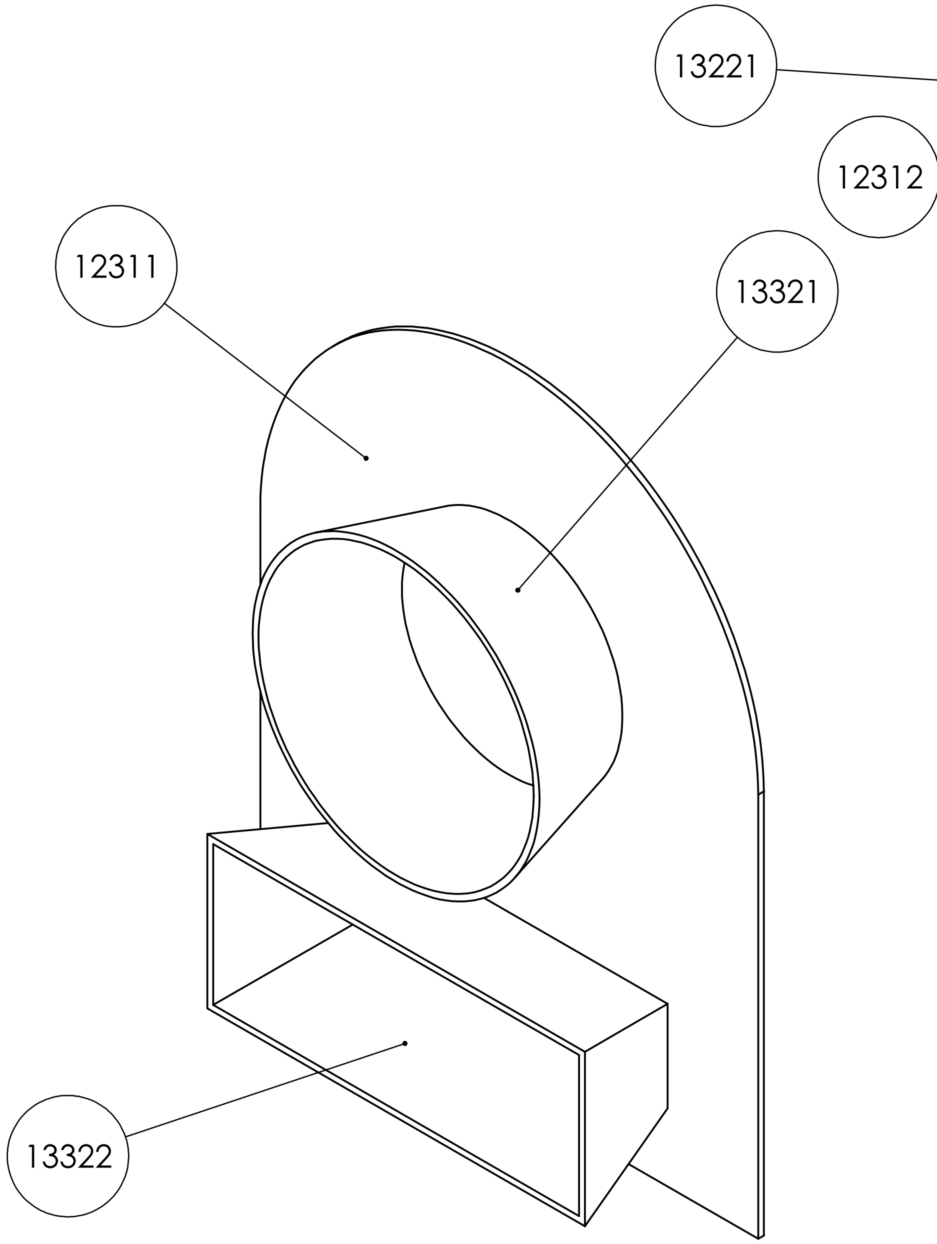
Cal Poly Mechanical Engineering	Senior Project	Part #12213	Title: Top Hatch Rear Hoop	Drawn by: Andrew Nott
ME 428/429/430	RSVP Spaceship	Revision: 1.0	Date: 01/29/20 / Scale: 1:4	Checked by: Taylor Chavez

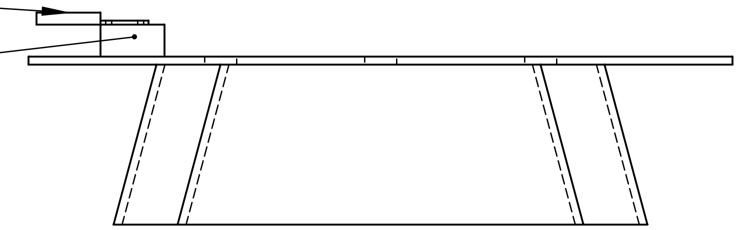


NOTES
UNLESS OTHERWISE SPECIFIED
1. ALL DIMENSIONS IN INCHES
2. TOLERANCES:
X = ±.1
X.X = ±.05
X.XX = ±.01
ANGLES = ±2°

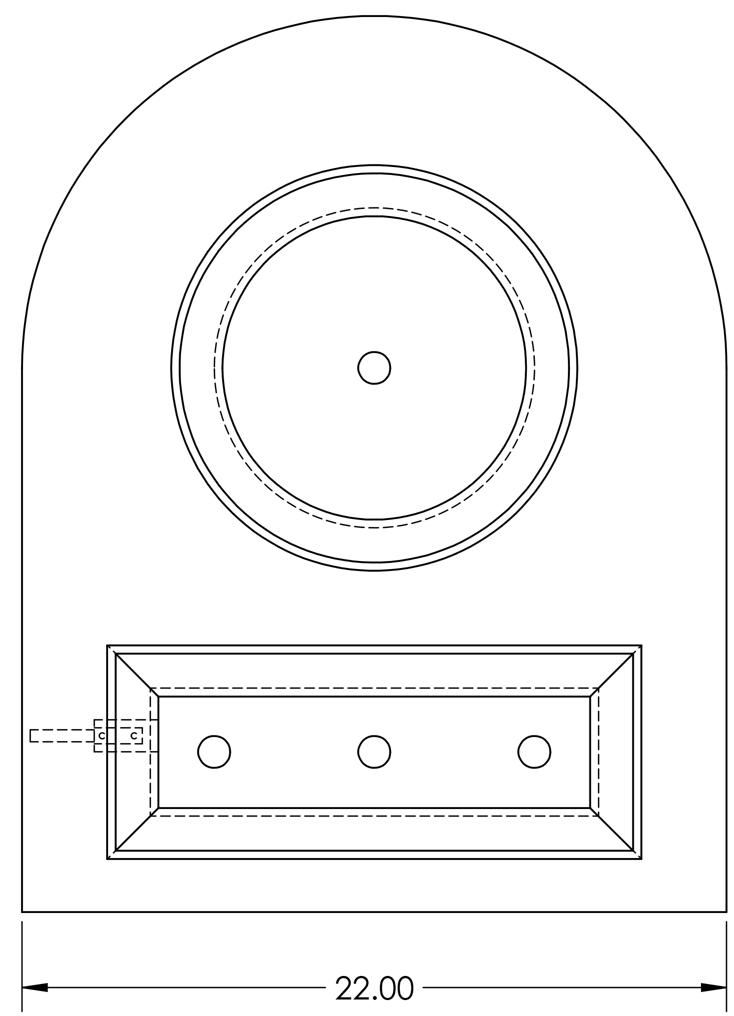
MANUFACTURE BY THERMOFORMING THE PLASTIC ONTO A WIRE MESH ATTACHED TO THE FRAME

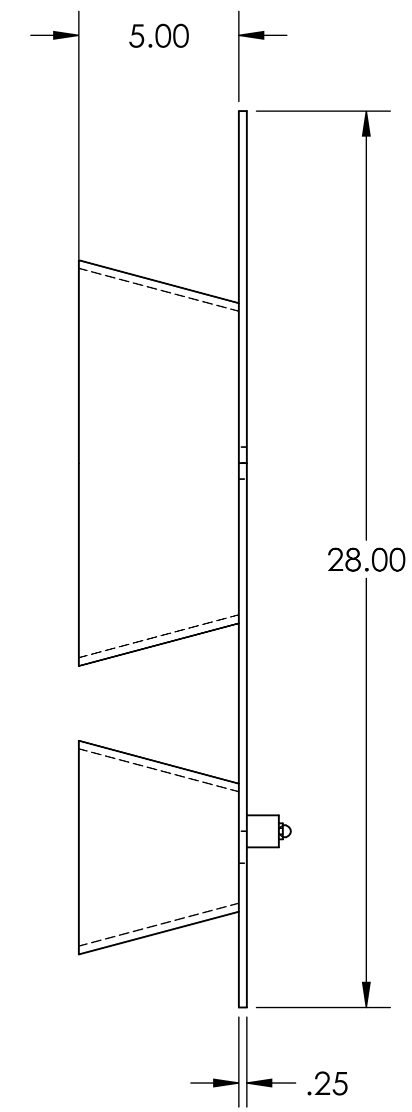
Material	Cal Poly Mechanical Engineering	Senior Project	Part #12220	Title: Top Hatch Shell	Drawn by: Andrew Nott
Thermoplastic	ME 428/429/430	RSVP Spaceship	Revision: 1.0	Date: 01/29/20 Scale: 1:10	Checked by: Taylor Chavez





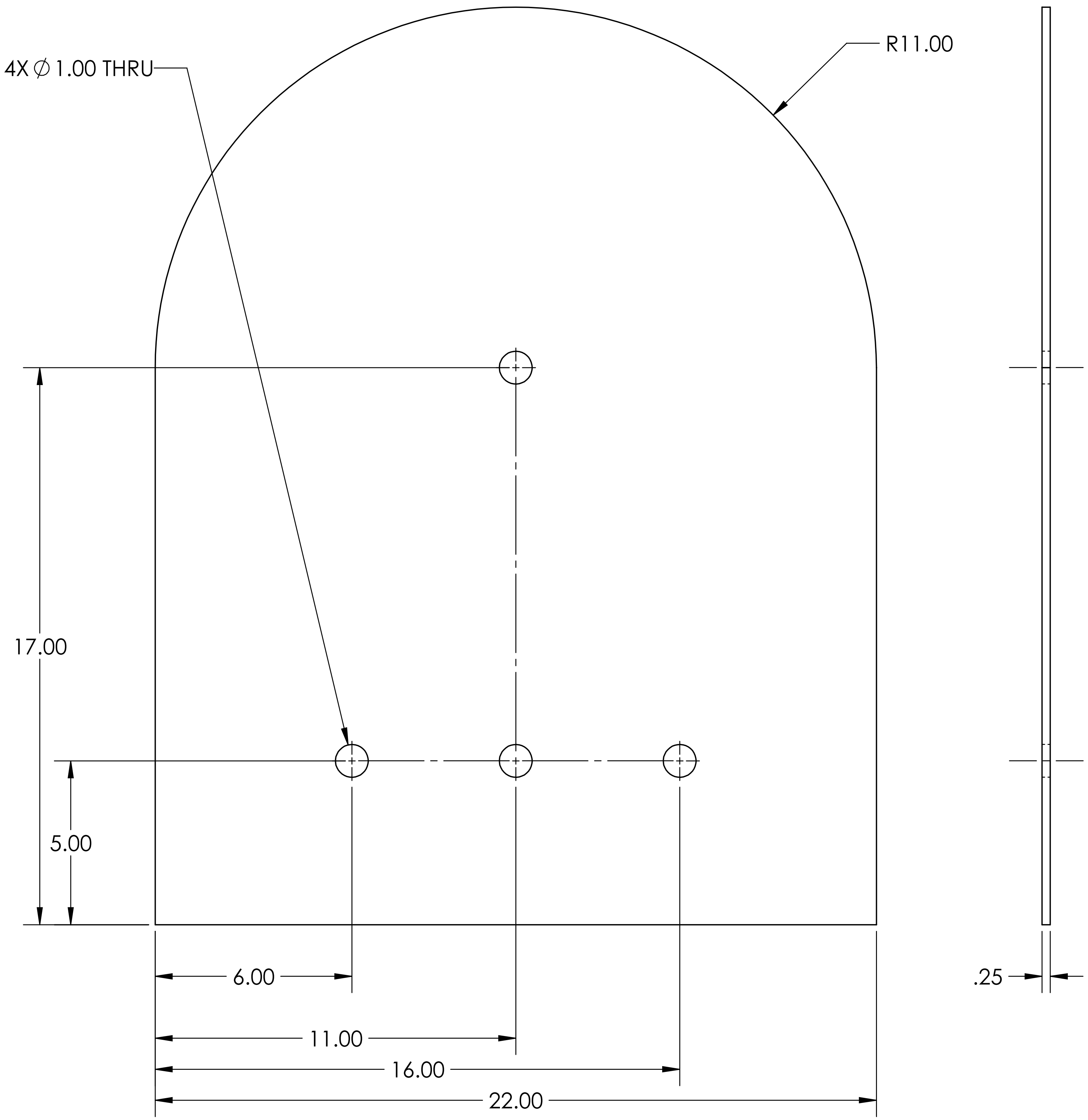
NOTES
UNLESS OTHERWISE SPECIFIED
1. ALL DIMENSIONS IN INCHES
2. TOLERANCES:
X.XX = $\pm$.01
X.XXX = $\pm$.005
ANGLES = $\pm 2°$
3. INSIDE TOOL RADIUS .02 MAX
4. BREAK SHARP EDGES .01 MAX

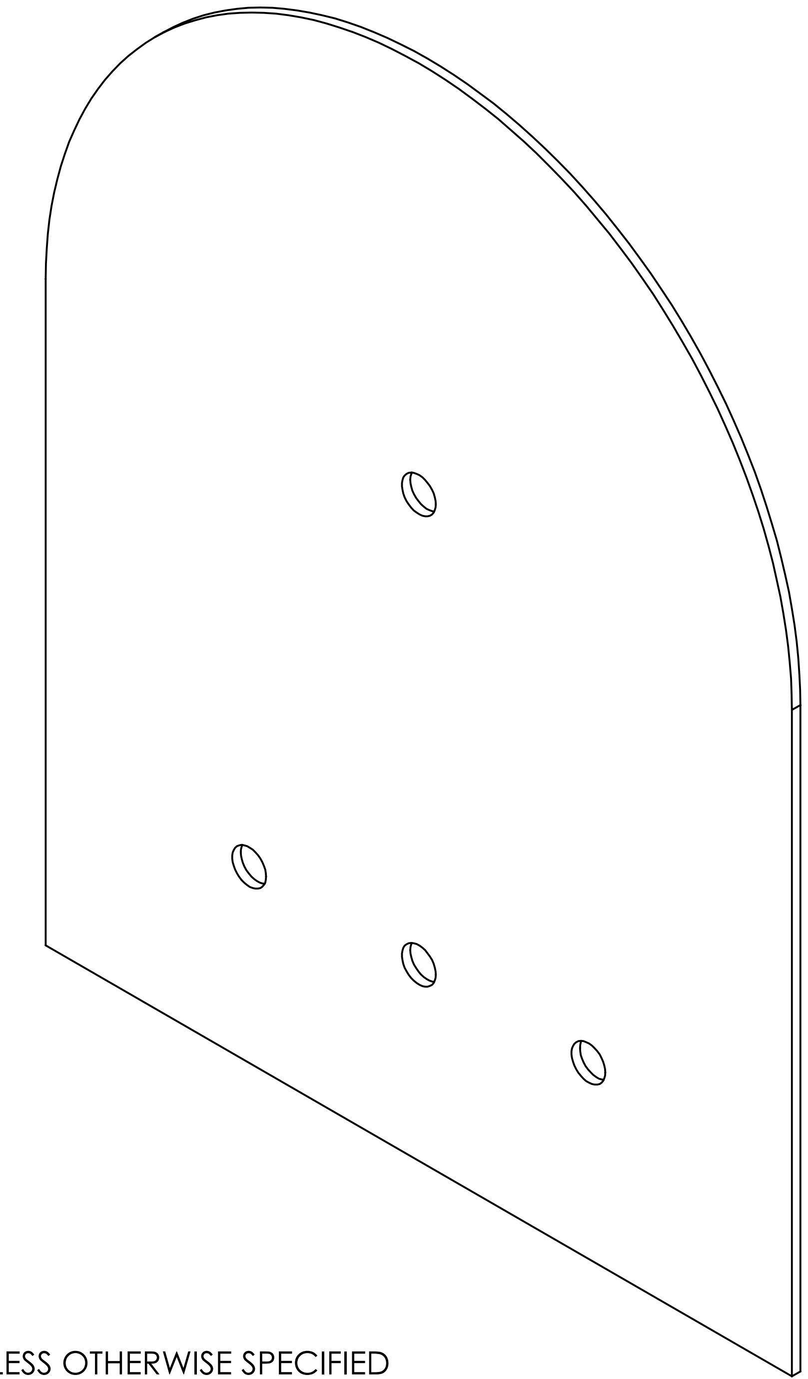




ITEM NO.	PART NUMBER	MATERIAL	QTY.
12311	Thruster Plate	1/4" MDF	1
12312	1x1 2in	1x1" Square Dowel Rod	1
13221	Gate Peg	-	1
13321	Circular Thruster	Lamp Shade	1
13322	RECTANGULAR THRUSTER	1/4" MDF	1

Cal Poly Mechanical Engineering	Senior Project	Part #12300	Title: Rear Hatch		Drawn by: Andrew Nott
ME 428/429/430	RSVP Spaceship	Revision: 1.0	Date: 01/29/20	Scale: 1:6	Checked by: Taylor Chavez

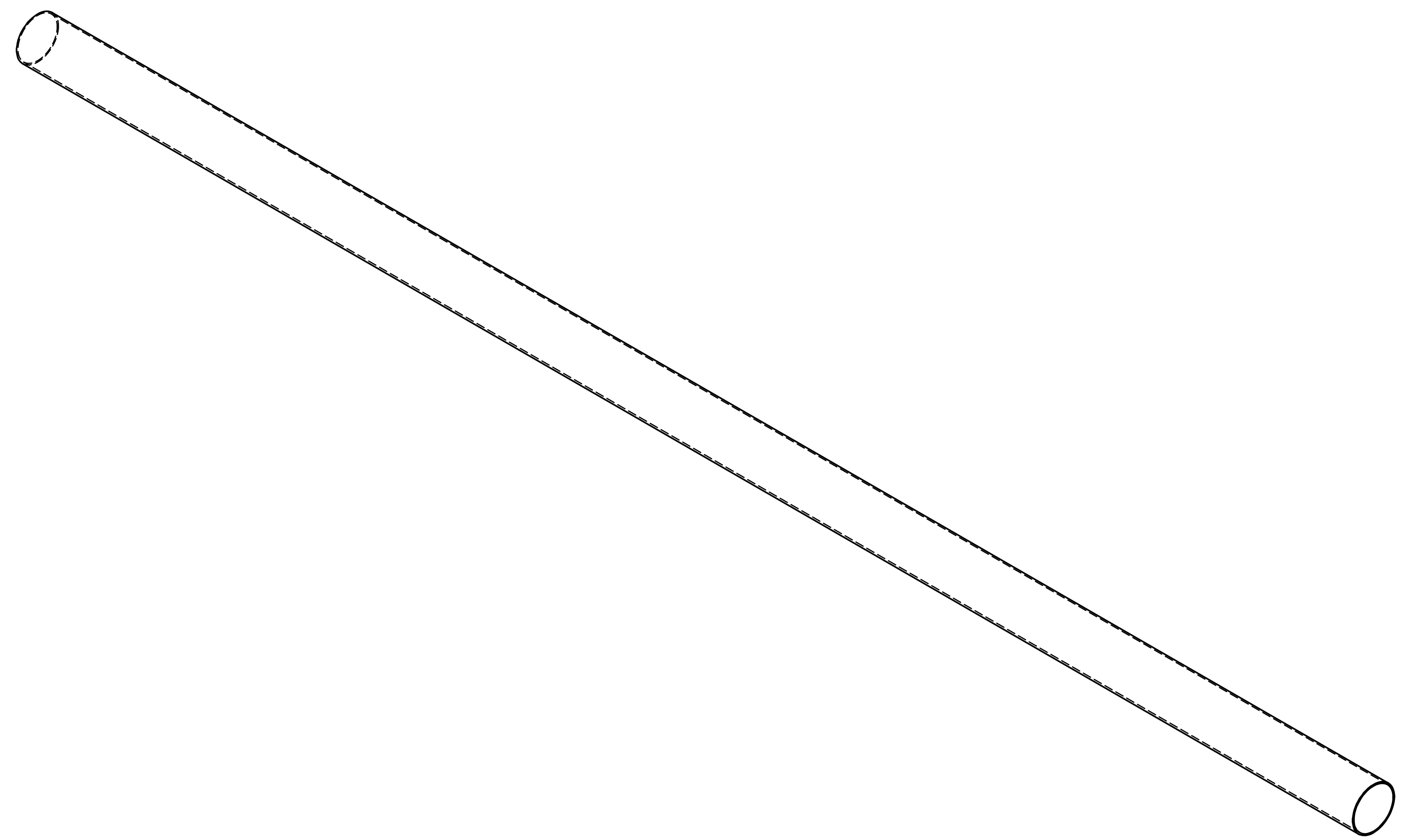




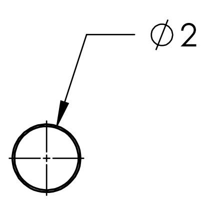
NOTES
UNLESS OTHERWISE SPECIFIED
1. ALL DIMENSIONS IN INCHES
2. TOLERANCES:
X = ±.1
X.X = ±.05
X.XX = ±.01
ANGLES = ±2°

HOLES ARE OUTLETS FOR FLEXIBLE FOG TUBES

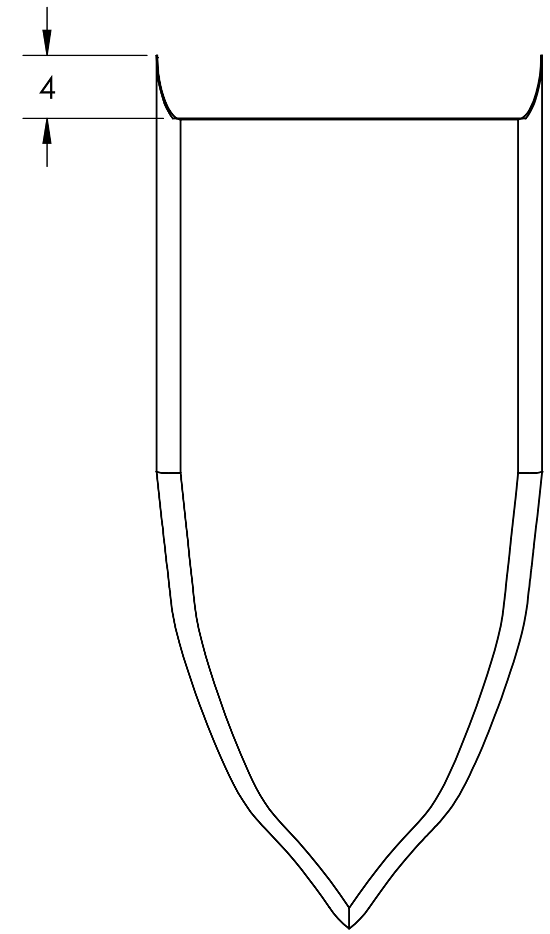
Material	Cal Poly Mechanical Engineering	Senior Project	Part #12311	Title: Thruster Plate		Drawn by: Andrew Nott
1/4" MDF	ME 428/429/430	RSVP Spaceship	Revision: 1.0	Date: 01/28/20	Scale: 1:4	Checked by: Taylor Chavez

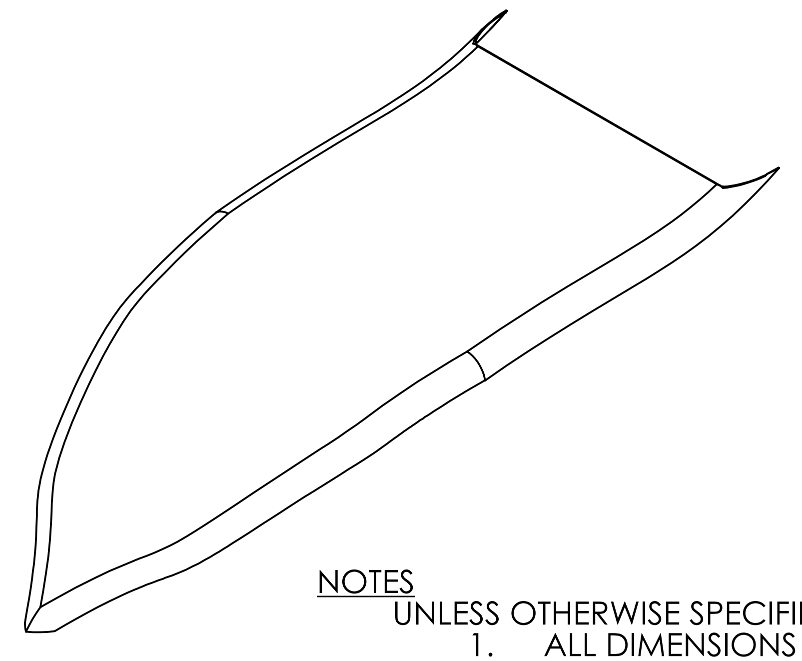


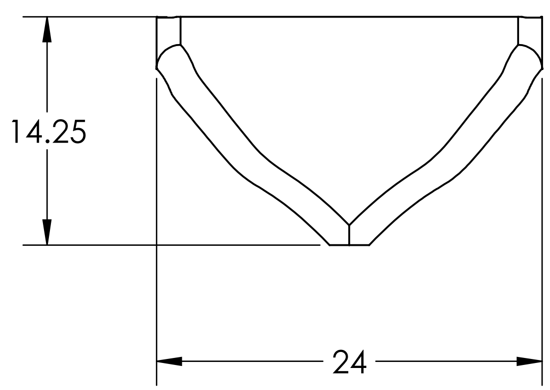
NOTES
UNLESS OTHERWISE SPECIFIED
1. ALL DIMENSIONS IN INCHES
2. TOLERANCES:
X = ±.1
X.X = ±.05
X.XX = ±.01
ANGLES = ±2°

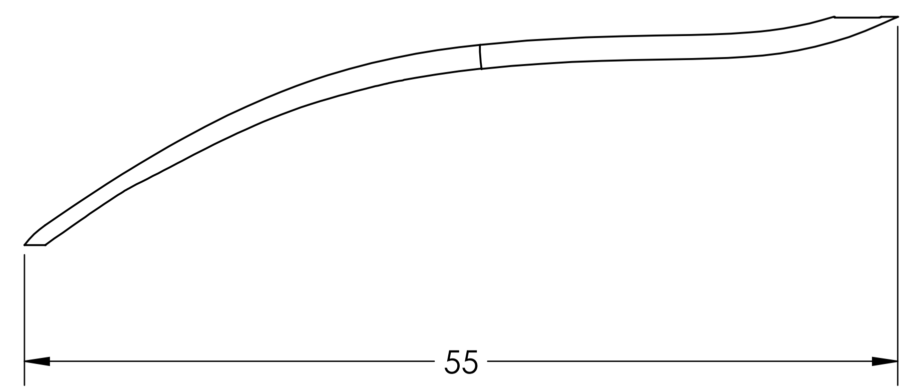


Material	Cal Poly Mechanical Engineering	Senior Project	Part #12321	Title: Thruster Pipe		Drawn by: Andrew Nott
2" PVC Pipe	ME 428/429/430	RSVP Spaceship	Revision: 1.0	Date: 01/29/20	Scale: 1:6	Checked by: Taylor Chavez





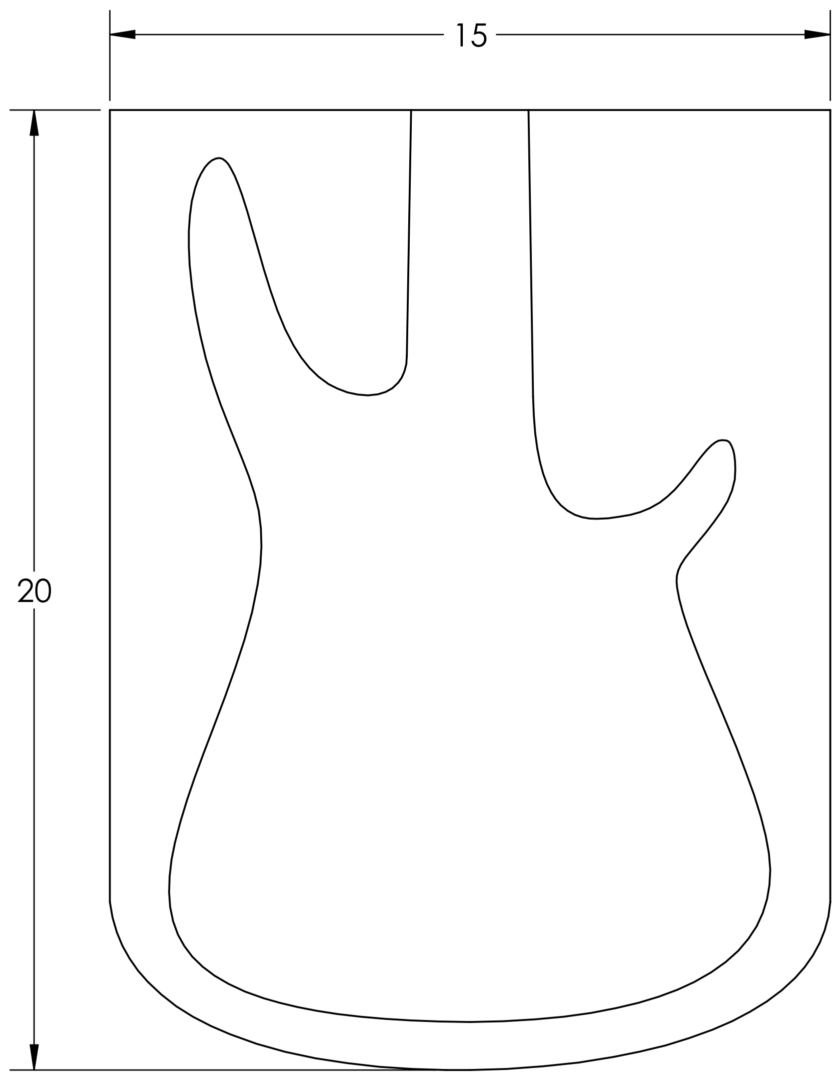


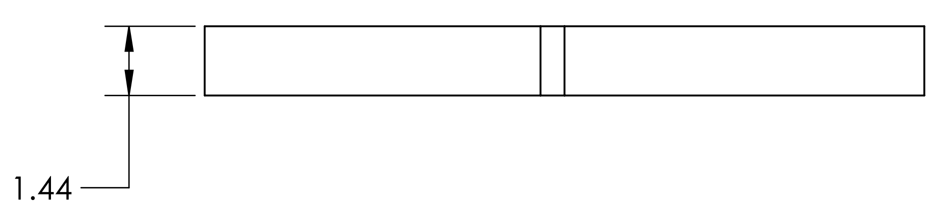


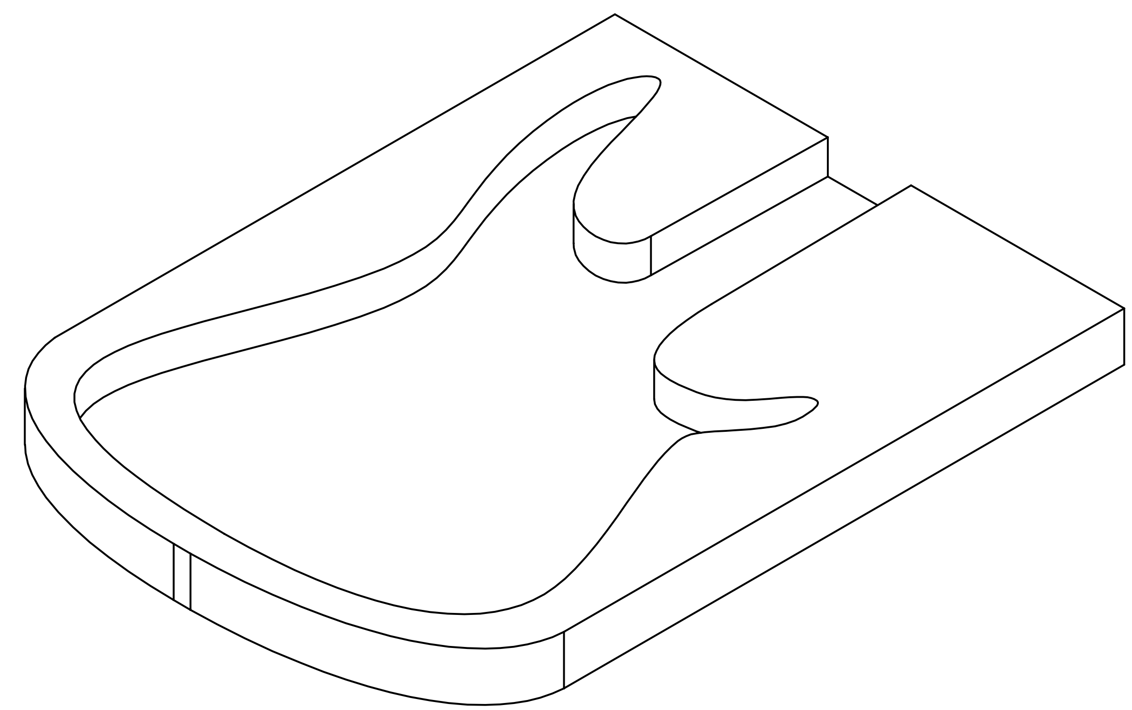
NOTES
UNLESS OTHERWISE SPECIFIED
1. ALL DIMENSIONS IN INCHES
2. TOLERANCES:
X = ±.1
X.X = ±.05
X.XX = ±.01
ANGLES = ±2°

MOLD PLASTIC OVER WIRE MESH WITH HEAT GUN

Material Thermoplastic	Cal Poly Mechanical Engineering ME 428/429/430	Senior Project	Part #12410	Title: Fuselage Shell Hood		Drawn by: Andrew Nott
		RSVP Spaceship	Revision: 1.0	Date: 01/29/20	Scale: 1:12	Checked by: Taylor Chavez



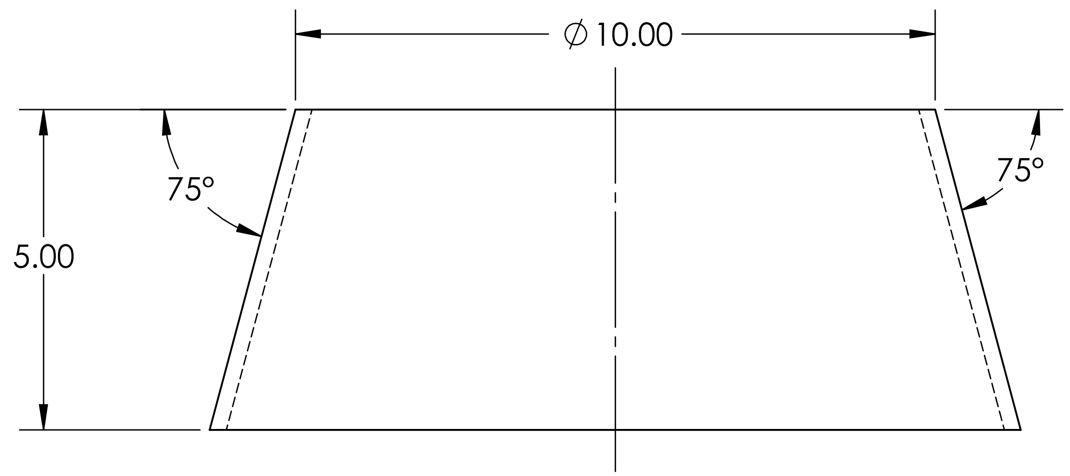


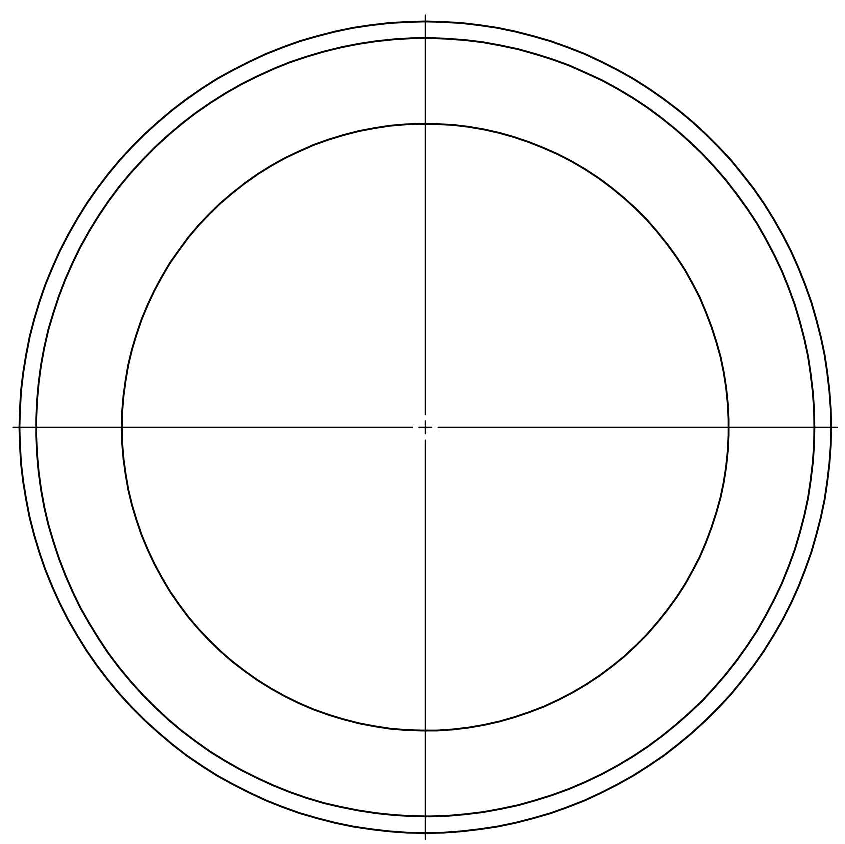


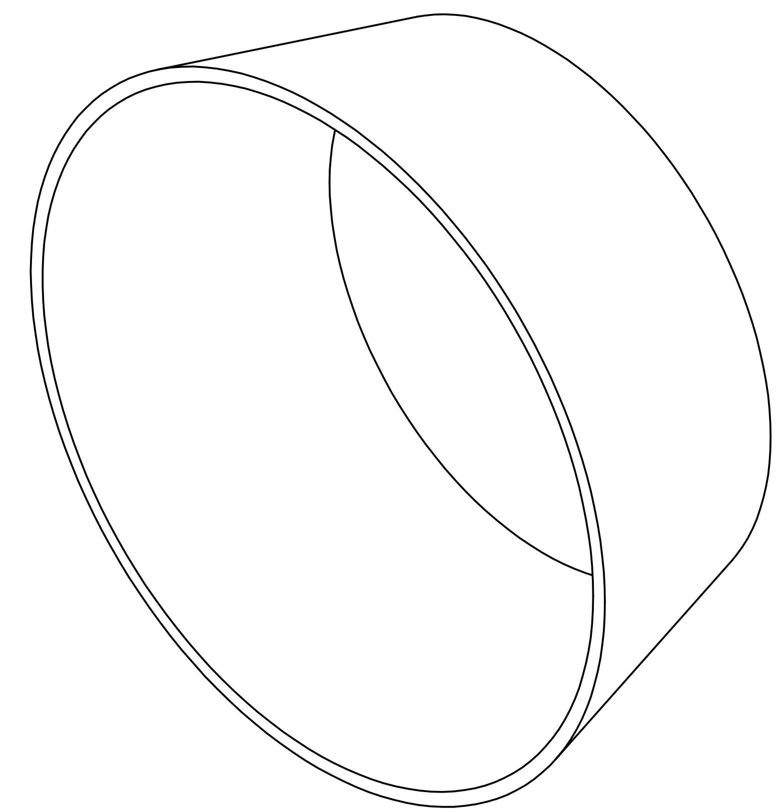
NOTES
UNLESS OTHERWISE SPECIFIED
1. ALL DIMENSIONS IN INCHES
2. TOLERANCES:
X = ±.1
X.X = ±.05
X.XX = ±.01
ANGLES = ±2°

WILL BE CUT FROM EXISTING GUITAR CASE
INTERIOR CURVES WILL NOT BE MANUFACTURED

Material	Cal Poly Mechanical Engineering	Senior Project	Part #13260	Title: Guitar Case		Drawn by: Andrew Nott
N/A	ME 428/429/430	RSVP Spaceship	Revision: 1.0	Date: 01/29/20	Scale: 1:4	Checked by: Taylor Chavez





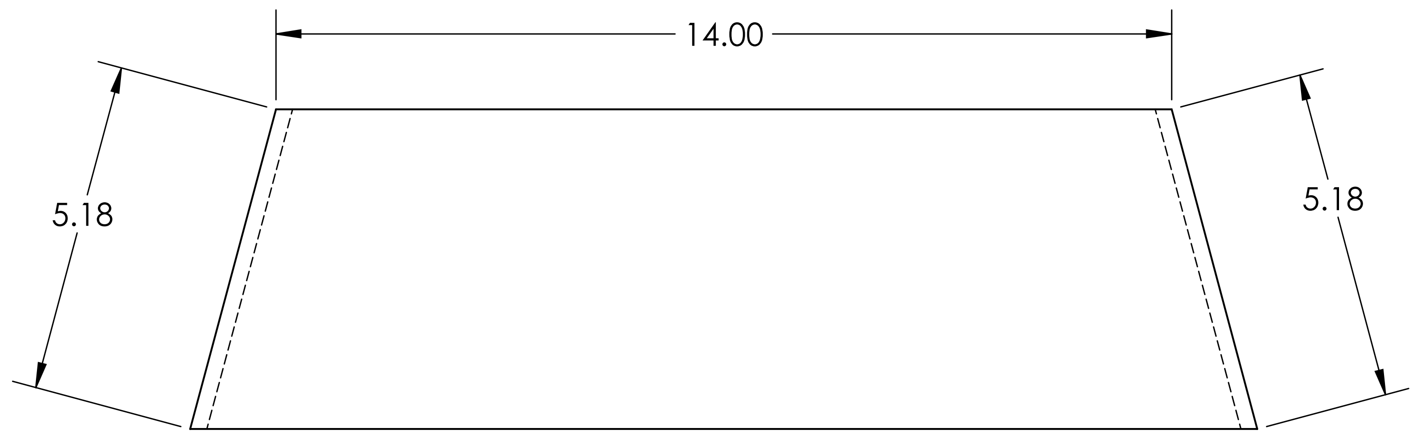


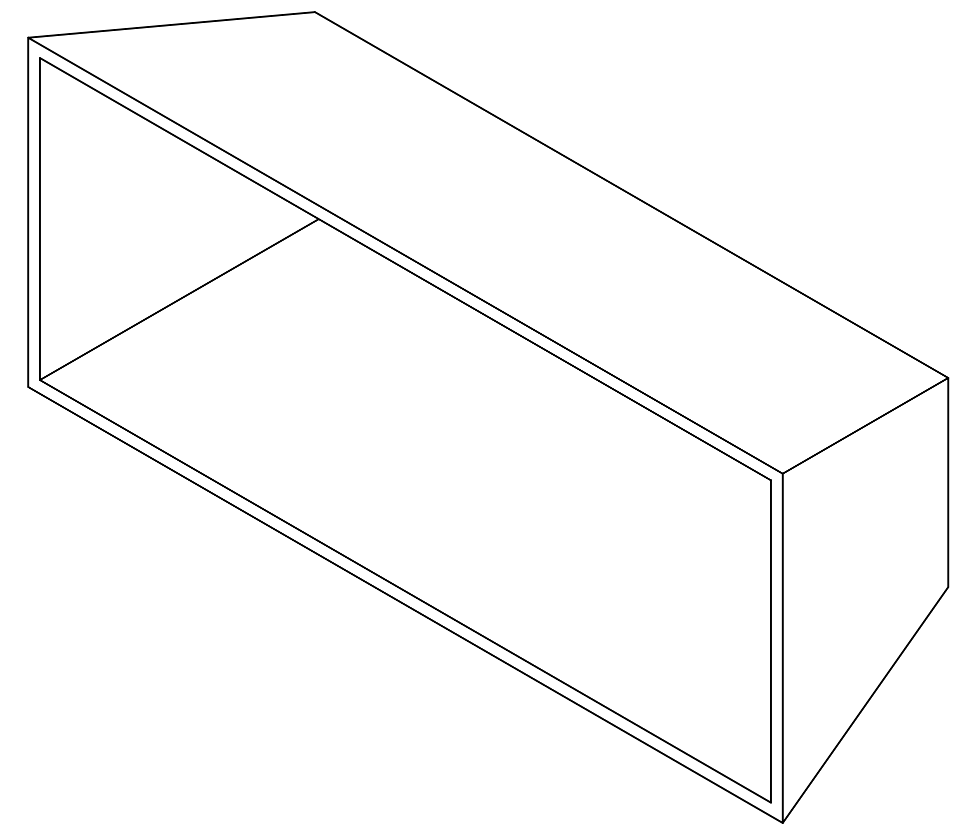
NOTES

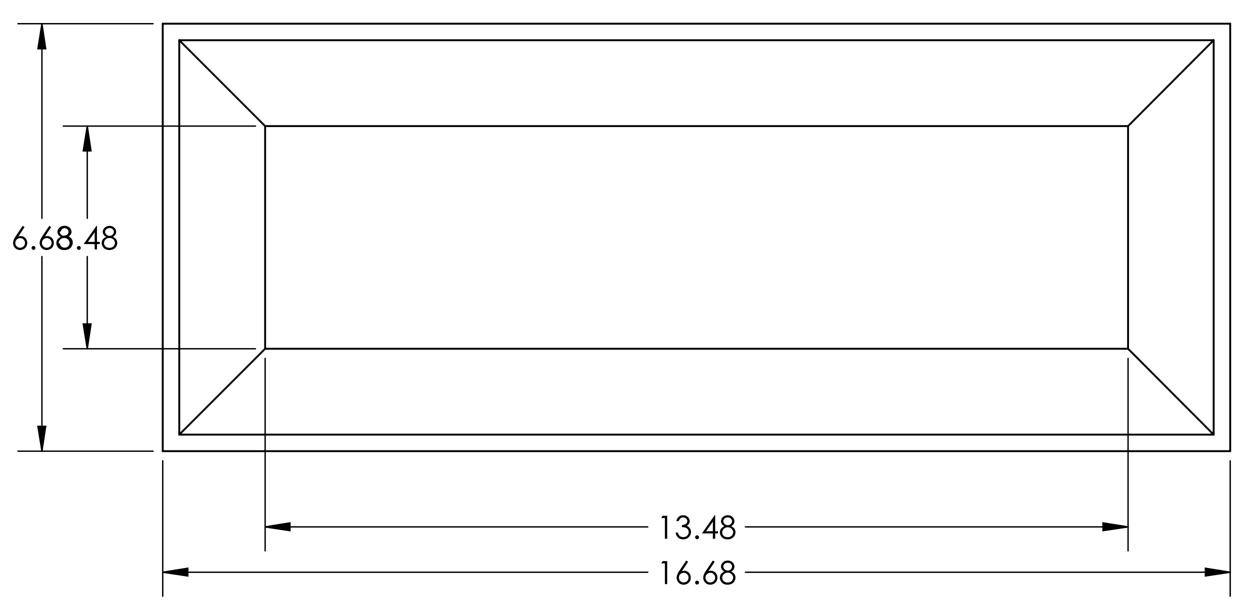
UNLESS OTHERWISE SPECIFIED

1. ALL DIMENSIONS IN INCHES
2. TOLERANCES:
   X = ±.1
   X.X = ±.05
   X.XX = ±.01
   ANGLES = ±2°

Material Undetermined	Cal Poly Mechanical Engineering	Senior Project	Part #13321	Title: Circular Thruster		Drawn by: Andrew Nott
	ME 428/429/430	RSVP Spaceship	Revision: 1.0	Date: 01/28/20	Scale: 1:3	Checked by: Taylor Chavez







NOTES
UNLESS OTHERWISE SPECIFIED
1. ALL DIMENSIONS IN INCHES
2. TOLERANCES:
X = ±.1
X.X = ±.05
X.XX = ±.01
ANGLES = ±2°

Material 1/4" MDF	Cal Poly Mechanical Engineering ME 428/429/430	Senior Project	Part #13322	Title: Rectangular Thruster		Drawn by: Andrew Nott
		RSVP Spaceship	Revision: 1.0	Date: 01/29/20	Scale: 1:3	Checked by: Taylor Chavez